UNCLASSIFIED

AD NUMBER

AD900236

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; Jan 1972. Other requests shall be referred to USAF Mission Analysis Study Group, Randolph AFB, TX.

AUTHORITY

USAF ltr, 26 Jul 1973

THIS PAGE IS UNCLASSIFIED

FUTURE UNDERGRADUATE PILOT TRAINING:

1975 THROUGH 1990

MISSION ANALYSIS STUDY GROUP

VOLUME 1

FINAL REPORT

OTHER VOLUMES

VOLUME 1

FINAL REPORT

VOLUME 2

APPENDIX A: INTRODUCTION
APPENDIX B: CURRENT UPT SYSTEM
APPENDIX C: TRAINING REQUIREMENTS ANALYSIS
APPENDIX D: EXTERNAL INFLUENCES OF FUTURE UPT

VOLUME 3

APPENDIX E: FUTURE UPT INSTRUCTIONAL CONCEPTS
APPENDIX F: FUTURE UPT TRAINING MEDIA

VOLUME 4

APPENDIX G: DEVELOPMENT & REFINEMENT OF ANALYTICAL TOOLS
APPENDIX H: DEFINITION OF ALTERNATIVE FUTURE UPT SYSTEMS

VOLUME 5

APPENDIX I: EVALUATION OF ALTERNATIVE FUTURE UPT SYSTEMS
APPENDIX J: UPT MISSION ANALYSIS FINDINGS

This is Volume 1 of the Mission Analysis on Undergraduate Pilot Training: 1975 through 1990. This Final Report, Volume 1, presents major findings of the Study Group and a synopsis of the supporting analysis. The purpose of this Final Report is to highlight the major issues and present findings on how Future Undergraduate Pilot Training should develop over the next nineteen years.

Volume 2 contains the first four appendixes, which present the current UPT system, an analysis of future training requirements, and the external influences on Future Undergraduate Pilot Training. Volume 3 presents Future UPT instructional concepts and future training media, Volume 4 describes the analytical models used with computers to determine the analytical findings and a definition of the alternative Future UPT systems, and Volume 5 presents evaluation methods and sensitivity analysis as well as the findings of the Study Group during the course of the Mission Analysis.

The findings presented in these volumes are those of the Study Group and do not necessarily reflect the policy or position of the Air Force. The work of the Study Group has been reviewed for technical quality and adequacy by a General Officer Steering Committee.

Colin J.N. Chauret

COLONEL COLIN J.N. CHAURET, STUDY DIRECTOR
UPT MISSION ANALYSIS
Randolph AFB, Texas

TABLE OF CONTENTS

	Page
LIST OF ILLUSTRATIONS	ix
LIST OF TABLES	xi
GLOSSARY OF TERMS	xv
INTRODUCTION (APPENDIX A)	1
Reasons for Mission Analysis	1
Equipment Deficiencies	1
Flight Simulation	1
Training Improvements	2
Mission Analysis Approach	2
Systems Approach (SAT)	2
Cautions	3
CURRENT UPT SYSTEM (APPENDIX B)	4
TRAINING REQUIREMENTS ANALYSIS (APPENDIX C)	8
Representative Future Operational Aircraft Selection	8
Methodology for Deriving Training Requirements	10
Future Training Requirements	12
Course Training Standard	14
EXTERNAL INFLUENCES (APPENDIX D)	15
Future UPT Production Rates	15
Graduate Assignment Distribution	16
Student Pool	17
Student Screening and Selection	19
Pending Changes -- Centralized T-41	24
Alternatives	24
Characteristics of the Future System	27
Costs of a Selection System	28
Conclusions	29

	Page
Airspace and Air Traffic Control	29
FUTURE UPT INSTRUCTIONAL CONCEPTS (APPENDIX E)	33
Curriculum Options	33
Pilot Training Concepts	34
Generalized Curriculum Features	34
Specialized Curriculum Features	35
Candidate Curriculum Patterns	35
Philosophical Training Concepts	36
Associationist Theories	36
Stimuli-Response Theories	37
Cognitive Theories	38
Motivation and Personality Theories	39
Summary	40
Systems Approach to Training	40
Development	41
Application	41
Summary	43
Training Rate	43
Student Evaluation	45
Student Management	46
Instructor Personnel	47
Dynamic Observer	49
FUTURE UPT TRAINING MEDIA (APPENDIX F)	50
Classroom and Learning Center	50
Procedures Trainers	53
Flight Simulation	55
Major Arguments	55
Simulation Designs	57
Summary	61
Future Trainer Aircraft	61
Design Philosophy	61
New Trainer Aircraft	65
Current Trainer Aircraft	69
Summary	71

Page

DEVELOPMENT AND REFINEMENT OF ANALYTICAL TOOLS (APPENDIX G) 72

Equipment Life Expectancy Model 72

UPT System Model 74

Simplified Cost Model 78

DEFINITION OF ALTERNATIVE FUTURE UPT SYSTEMS (APPENDIX H) 79

Reduction of System Options 79

System Option Description. 82
Curriculum Design. 82
Curriculum 87
System Equipment Requirements. 91
Additional Facilities. 97
Total System Personnel Requirements. 98

MISSION ANALYSIS FINDINGS (APPENDIX I AND J) 100

Decision Tree Design. 100

System Options Evaluation 100

Option I-A, T-37/T-39. 103
Option II-A, T-37/T-38 103
Option II-B, TA-2/T-38 103
Option II-C, TA-3. 103
Option III-A, T-37/T-38/TA-4 105
Option III-B, TA-2/T-38/TA-4 106

System Option Costing 106

System Cost Data 106

Sensitivity Analyses 113

Mission Analysis Summary 114

STEERING COMMITTEE FINDINGS. 116

ANNEX I ADMINISTRATIVE A-1

LIST OF ILLUSTRATIONS

FINAL REPORT

Figure		Page
1	Mission Analysis Approach	2
2	Undergraduate Pilot Training Bases	6
3	UPT Graduate Assignments: Fighter/Attack/Interceptor/Reconnaissance (FAIR)	17
4	Pilot Training Attrition by Cause	21
5	Pilot Training Attrition within Sources	22
6	Cumulative Pilot Training Costs	24
7	Historical Trends of UPT Syllabus and Production	34
8	Future UPT Curriculum Options	35
9	SAT Model	42
10	Development of Attention Sharing Ability within a Learning Experience	44
11	Student Ability Distribution	47
12	Training Media Progression	50
13	A Standard UPT Classroom	51
14	Typical Learning Center Arrangement	52
15	Computer Based Instruction Capabilities	52
16	Training Media Progression	54
17	Cockpit Procedures Trainer Segment	54
18	Procedures Trainers Summary	55
19	Process for Deriving Flight Simulator Requirements	56
20	Artist's Concept of TS-2 Flight Simulator	57
21	Minimum Altitudes for Practice Approaches	59
22	Artist's Concept of TS-3	60
23	Two-Place Primary Trainer Aircraft, TA-2	65
24	Two-Place Basic Fighter Trainer Aircraft	67
25	Basic Bomber/Transport Trainer	67

List of Illustrations (cont'd)

Figure		Page
26	Two-Place Primary Trainer Aircraft, T-37	70
27	Two-Place Basic Fighter Trainer Aircraft	7[illegible]
28	UPT Systems Model #2	75
29	Curriculum Concepts	79
30	Commonality and Quality Continuum	80
31	Sample Worksheet	83
32	Decision Tree	101
33	System Cash Flow	107
34	Finalized Future UPT Options	116

LIST OF TABLES

FINAL REPORT

Table		Page
I	Acreage and Location of UPT Bases	6
II	Training Organization Manning Levels Average UPT Base	7
III	1970 Personnel Complement at UPT Bases	7
IV	Aircraft Considered in Future UPT Mission Analysis	9
V	Future Training Requirements	13
VI	UPT Production Rates	15
VII	UPT Production Rates "TOPLINE"	16
VIII	Manpower Pool, 20.5-26.5 Year-Old Males, 1975 through 1990 (In Thousands)	18
IX	Fiscal Year 1969 UPT Attrition by Student Source and Training Phase	23
X	Outline of Selection Center Operations	27
XI	Required Facilities for Selection Center Validation	28
XII	FAA Forecast of Civil Aviation Fleet	30
XIII	FAA Forecast of Activity (In Millions)	30
XIV	Comparison of Current Syllabi	44
XV	Future Trainer Aircraft -- Performance Requirements	62
XVI	Future Trainer Aircraft -- Equipment Requirements	63
XVII	Primary Trainer Aircraft Performance	66
XVIII	Basic Fighter Trainer Aircraft Performance	68
XIX	Basic Transport/Bomber Trainer Aircraft Performance	69
XX	UPT Comparative Operating Costs, T-37 Phase	77
XXI	UPT Comparative Operating Costs, T-38 Phase	78
XXII	Future UPT System Options	81
XXIII	Alternative Systems Analysis	82
XXIV	UPT Practice Approach Minimums (Average)	84
XXV	Instrument Approach Data	85

List of Tables (cont'd)

Table		Page
XXVI	Instrument Approach Comparisons	86
XXVII	Future UPT System Options	87
XXVIII	Concept I-A Baseline	87
XXIX	Concept I-A Primary	88
XXX	Concept II-A and -B	89
XXXI	Concept II-C	90
XXXII	Concept III-A and -B	90-91
XXXIII	Curriculum Summary (Systems Employing TS-2 Simulator)	92
XXXIV	Curriculum Summary (Systems Employing TS-2/TS-3 Simulator)	93
XXXV	Equipment Summary (Systems Employing TS-2) 3665 Graduate Production	94
XXXVI	Equipment Summary (Systems Employing TS-2/TS-3 Simulator) 3665 Graduate Production	95
XXXVII	Additional Facilities Required (Systems Employing TS-2 Simulators)	97
XXXVIII	Additional Facilities Required (Systems Employing TS-2/TS-3 Simulators)	98
XXXIX	Permanent Party Personnel (Systems Employing TS-2 Simulators)	98
XL	Permanent Party Personnel (Systems Employing TS-2/TS-3 Simulators)	99
XLI	Student Personnel Summary (Systems Employing either TS-2 or TS-2/TS-3 Simulator)	99
XLII	TS-2 Program Phase	102
XLIII	TS-3 Program Phase	102
XLIV	TA-2 Program Phase	104
XLV	TA-3 Program Phase	104
XLVI	TA-4 Program Phase	105
XLVII	System Cost Data, TS-2	108
XLVIII	System Cost Data, TS-2/TS-3	108
XLIX	Cost Ranking	109

List of Tables (cont'd)

Table		Page
L	System Cost Data, TS-2/TS-3	110
LI	System Characteristics, TS-2/TS-3 Simulators	110
LII	System Cost Data (Generalized 20 Training Requirements)	111
LIII	Cost Impact of Simulation	112
LIV	System Cost Data, TS-2/TS-3	112
LV	System Cost Data, TS-2/TS-3	113
LVI	Factors considered in Sensitivity Analyses	112
LVII	Factors with Large Impact	114
LVIII	Cost for One Hour Change	114

GLOSSARY OF TERMS

AASCS	Automated Aircraft Sortie Control System
AFOQT	Air Force Officer Qualifying Test
AGE	Aerospace Ground Equipment
AGL	Above Ground Level
AIMS	A= Air Traffic Control Radar Beacon System (ATCRBS) I= Identification Friend or Foe M= Mark XII Indicator System S= Systems
APSI	Aero Propulsion Systems Integration
ALPA	Airline Pilots Association
AMM	Adaptive Mathematical Models
APC	Area Positive Control
ARMA	Aptitude Adaptibility Rating for Military Aeronautics
ARTCC	Air Route Traffic Control Center
ASSET	Advanced System Synthesis and Evaluation Techniques
ASUPT	Advanced Simulator for Undergraduate Pilot Training
ATCB	Air Traffic Control Board
ATCRB	Air Traffic Control Radar Beacon
ATEGG	Advanced Technology Engine Gas Generator
AVRS	Audio/Video Recording System
BMS	Base Management System
CAI	Computer Assisted Instruction
CAS	Collision Avoidance System
CCT	Combat Crew Training
CCTS	Combat Crew Training School
CIG	Computer Image Generation
CMI	Computer Managed Instruction
CMS	Command Management System
CPT-1	Cockpit Procedures Trainer (Noncomputing)
CPT-2	Cockpit Procedures Trainer (Computing)
CRPS	Command Resources Programming System
CRT	Cathode Ray Tube
CTS	Course Training Standard
CUPT	Current Undergraduate Pilot Training
DCM	Deputy Commander Material
DCPR	Defense Contractor Planning Report
DCO	Deputy Commander for Operations (Group C.O.)
DDT&E	Design Development Testing & Evaluation
DF	Direction Finder
DH	Decision Height
DME	Distance Measuring Equipment
DoDI	Department of Defense Instruction
DOF	Degrees of Freedom
DOX	Operational Plans Directorate
EACP	Enlisted Airman's College Program
ELEM	Equipment Life Expectancy Model
EPPT	Electronic Performance
EPT	Electronic Perspective Transformation
ETIC	Estimated Time In Commission

FAA	Federal Aviation Agency
FAIR	Fighter/Attack/Interceptor/Reconnaissance
FFT	Formation Flight Trainer
FIP	Flying Indoctrination Program
FL	Flight Level
FOD	Foreign Object Damage
FTA	Fighter Training Aircraft
FUPT	Future Undergraduate Pilot Training
g's	Symmetrical load factors (gravity)
GCA	Ground Control Approach
GCI	Ground Control Intercept
GAT	General Aviation Trainer
GEP	Graduate Evaluation Program
HRL	Human Research Lab
HumRRO	Human Resources Research Organization
IFO	Automatic Instructor Feedback & Override
IFR	Instrument Flight Rules
IFS	In-Flight Simulator
ILS	Instrument Landing System
IO	Input/Output
IOC	Initial Operational Capability
IP	Instructor Pilot
IRAN	Inspection & Repair as Necessary
IPC	Intermittent Positive Control
IPIS	Instrument Pilot Instructor School
ISD	Instructional Systems Development
ISE	Instructional System Engineering
ISJTA	Intensive Student Jet Training Area
JFS	Jet Fuel Startor
KIAS	Knots Indicated Air Speed
KOR	Knowledge of Results
KR	Knowledge of Results
MAP	Military Assistance Program
MDA	Minimum Descent Altitudes
MOA	Motivation & Stress
MRT	Modular Readiness Training
MQT	Model Qualification Test
MS	Maximum Substitution: flight hours to simulator hours
MSL	Mean Sea Level
NSA	National Airspace System
NavAids	Navigation Aids
NPV	Net Present Value
OFP	Operational Force Pilots

PAR	Precision Approach Radar
PAS	Professor of Air Science
PCA	Positive Control Airspace
PFRT	Preliminary Flight Rating Test
PFT	Program Flying Training
PIP	Pilot Indoctrination Program
PPDR	Pilot-Performance Description Record
PTS	Pilot Training Squadron
PWI	Pilot Warning Indicators
RAPCON	Radar Approach Control
RNAV	Area Navigation Routes
RSU	Runway Supervisory Unit
SAAC	Simulator for Air-to-Air Combat
SAT	Systems Approach to Training
SBO	Special Behavioral Objective
SCM	Simplified Cost Model
SEA	Southeast Asia
SFTS	Synthetic Flight Training Simulator
SI	Systematized Instruction
SFG	Automatic Student Feedback & Guidance
SID	Standard Instrument Departure (procedures)
SIE	Self Initiated Elimination
S & L	Supply and Logistics
Stan/Eval	Standardization/Evaluation
STAR	Standard Terminal Arrival Route
TA	Training Aircraft
TACAN	Tactical Air Navigation
TBO	Time Between Overhaul
TCA	Terminal Control Areas
TCTO	Time Compliance Technical Orders
TER	Training Effectiveness Ratio
TM&E	Training Measurement & Evaluation
TOPLINE	Total Officer Personnel Objective Structure for the Line Officer Force
TR	Training Requirements
TRAC	Teaching Research Automated Classroom
TRACON	Terminal Radar Control
TRCO	Technical Representative of the Contracting Officer
TS	Training Simulator
TTB	Tanker/Tactical & Strategic Transport/Bomber
UDL	Unit Detail Listing
UHT	Undergraduate Helicopter Training
UPT	Undergraduate Pilot Training
VAMP	Visual Amorphic Motion Picture
VFR	Visual Flight Rules
VOR	Visual Omni-Range
VORTAC	Visual Omni-Range Tactical Air Navigation
WUC	Work Unit Cost

INTRODUCTION (APPENDIX A)

The final report is a summarizing document supported by ten appendixes of detailed analyses that comprise the complete Mission Analysis Report.

The report represents a major effort by the U.S. Air Force to define a complete pilot training system designed to meet the force structure requirements projected for the 1975 to 1990 time period.

The significant findings of the Mission Analysis are presented in this Final Report. The appendix title and letter designation is given in Bold type at the beginning of each summary.

Reasons for Mission Analysis

The impetus for the analysis was provided by several important factors:

Equipment Deficiencies

The most important of these was the projected deficiencies in training equipment. At the time the study was initiated, the high UPT production level was rapidly driving the trainer aircraft fleet to insufficiency in number, and the ground trainer equipment to retirement.

After the analysis effort was well along (approximately three months prior to scheduled completion) a major decrease in UPT production was directed by USAF Headquarters. This reduction extended the life of the current trainer aircraft significantly and affected the options available for conducting Future Undergraduate Pilot Training.

The urgency of decision on equipment purchases was reduced. However, even with the cut in production, certain Future UPT system options still have near term critical decision dates. The decision on equipment purchases is critical not only because it involves a large resource commitment, but also because it determines the alternatives available in conducting the training.

A complete analysis of the training program and its requirements allows equipment purchase options to be analyzed in terms of training alternatives.

Flight Simulation

The tremendous technical advances made in simulation raised the question as to why simulators were not being used in Undergraduate Pilot Training. The important aspect of this question concerned the exchange of simulator training for aircraft training. The Mission Analysis approach permitted a thorough review of simulator technology and its impact on the Future UPT Training system.

Training Improvements

The final factor concerned the actual training process. The development of the current UPT program was recognized for its efficiency. However, few substantive changes in training concepts have been made in the pilot training process. The hypothesis was made that the research efforts on learning theory and its application should provide some breakthroughs in the conduct of pilot training.

The Mission Analysis was charged to investigate the full range of learning theory application and to employ those concepts that provide advantages in the total training system.

Mission Analysis Approach

The organization of the study was critical from the standpoint of priorities. Figure 1 shows the overall approach that was employed. It is interesting to note the priority of training requirements over system elements -- instructional concepts, the aircraft, and other training equipment.

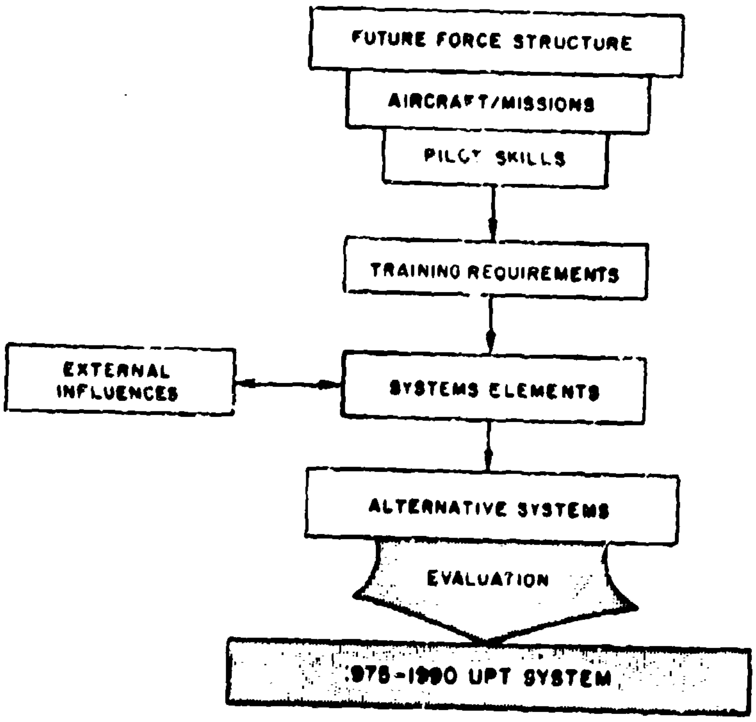


Figure 1. Mission Analysis Approach

It has always been assumed in the pilot training process that designing the trainer aircraft to have like performance with front line operational aircraft ensured that the training requirements would be fulfilled.

The mission analysis approach challenges this assumption and examines the future training requirements from both a task analysis of pilot skills and a commonality analysis of these skills. The training equipment is then designed to accomplish the training requirements.

Systems Approach (SAT)

The Systems Approach to Training (SAT) is applied in arriving at all the alternative training systems. Actually, there is no magic in this concept. It is simply a detailed plan of training activity that starts with the training requirements and systematically applies the most appropriate training equipment as well as the necessary amount of training to achieve the desired results.

The significant aspects of the systems approach to training that distinguish it from more conventional training approaches are its implicit requirement for a rigid training schedule and a very detailed definition of the training requirements. The Systems Approach to Training does not allow for any degree of overtraining, and, as such, it produces a training system that is austere and economical.

The SAT concept combines the training requirements and the various system elements into alternative training systems that represent the optimum plan for achieving the training goals. The Systems Approach to Training will be addressed in more detail later in the report.

Cautions

As always, when considering an overall system analysis of this magnitude one must be concerned over the concept of synergism -- where the characteristics of the whole system are unique from the characteristics of the respective subsystems.

In dissecting the various parts of the pilot training process, and exposing them to critical analysis, there was real concern that some of the essential essence of the process would be lost. For example, the concept of flight has, from its inception, been afforded a certain degree of mysticism, and men associated with it have been identified as possessing high purpose. Novice aviators are attracted by this challenge of flight and the uniqueness of the aviator's skill. As a result, the pilot training process involves more than a mastery of behavioral skills associated with controlling the flight vehicle; it must allow for the novices' psychological development -- a kindred feeling for the air. Although some might scoff at this requirement as being anachronistic in the age of technology, it is a real one, nonetheless.

Technology does not diminish the individual's sense of achievement or his need for identification. Even though flying is a routine occurrence today -- the cycle of development for a pilot with its anxieties, exhilarations, and high satisfactions remain unchanged. Gill Robb Wilson, the noted aviation writer, summarized this point well when he wrote:

> "It is rarely realized . . . that in the achievement of flight, men have to call more deeply on resources of heart and mind than in any previous reach of experience. There is nothing in man's physical nature which prepares him for flight. Countless generations have rooted human instincts in earth-bound habits . . . . As I contemplate all this after a lifetime of intimate association with it, I marvel at the depth of man's spiritual and intellectual resources more than at the altitudes and speeds of his flight."

How does one capture this type training requirement in a word picture or a description of a training task? The answer to this question is a complex one. The reason is, in making any kind of a prediction one must distinguish the future which depends on science and technology from the future which depends on human factors. As regards technology, there seems to be hardly any limits. However, the future depending on human factors will be determined by man's ability to adapt to the possibilities offered by technology. Therefore, to account for the integration of technology and human factors, and to ensure that manipulation of the parts of the pilot training process did not diminish the whole, the effect on the student was the guiding principle. Where new techniques were suggested, their advantages were required to be significant and implementation was not planned until positive validation had taken place.

In summary, the mission analysis approach was organized to examine the pilot training process in detail with the assurance that the overall analysis would provide a pilot training program designed to meet the requirements of the 1975 to 1990 time period while at the same time enhancing human factors to provide a well motivated and properly trained pilot graduate.

CURRENT UPT SYSTEM (APPENDIX B)

Before going into the details and findings of the Mission Analysis, it is necessary to present a brief description of the current UPT program. Although the current program is referred to throughout the entire report in a comparative way, it will be described here as a complete system to provide a feel for its scope and magnitude.

The current Undergraduate Pilot Training program represents an evolutionary development spanning the 68-year history of powered flight. The early development of flight training was essentially trial and error in pre- and post-Wright brother's days, gradually developing to a person-to-person explanation of some of the factors. Historical evidence of early learning modes is not readily available, but following the time period of the Second World War the development process can be easily traced and is especially well defined for the period from 1961 to the present.

Today, the UPT program represents an amalgamation of user requirements, training experience, and economic pressures. It must be considered a formidable baseline replete with historical precedent, trial-and-error validation, operational reality, and resource commitment. Current Undergraduate Pilot Training operates under the philosophy that all graduates should be "universally assignable"; therefore, all students receive the same training in the same training vehicles. The training vehicles follow the building-block concept of flight training with the T-41 low-performance aircraft used as a screening device and providing some introductory flight training. This initial phase of training is conducted using civilian contractor pilots at small civilian airports located near the UPT base. The second phase of training is accomplished in the T-37, a medium-performance jet trainer used as a fundamentals vehicle in which all phases of flight are introduced. Finally, the T-38 high-performance jet trainer is used to elevate fundamental skills and establish orientation to the capabilities of modern operational aircraft. Training in both T-37 and T-38 aircraft is conducted by military instructor pilots.

Ground training, in support of flight training, consists of lecture-oriented classroom subjects which are time-phased to provide the lead-in knowledge for flight application. Academic instruction is provided by qualified military instructor pilots who have been accredited for classroom teaching and by nonrated but classroom-accredited weather officers. Innovations in methodology such as programmed texts, learning centers, and student responder systems have been, or are being introduced. Additionally, all academic subjects are being reworked in both objectives and content to incorporate the "Systems Approach" to Training.

Ground-based simulation in Current UPT consists of nonmotion, nonvisual flight instrument trainers. These devices (not actually simulators) were introduced in the early 1960s. They provide a degree of validity with the aircraft, in that their cockpit instrument displays are representative. Control response validity is not good; however, the devices are used primarily as procedures trainers, and in this role the control response discrepancies are recognized as acceptable. Missions flown in these trainers are prerequisites for identical instrument missions in the aircraft. The UPT student receives instruction in these devices from nonpilot enlisted personnel.

Training missions flown in the air (after ground instruction prerequisites are completed) face a significant problem with available airspace. The airspace operating environment for UPT is characterized by stringent control, elaborate procedures, and high utilization.

Definitive airspace control for training aircraft began in 1963. With intense planning efforts and increased radar coverage, the majority of training operations are controlled under Instrument Flight Rules (IFR). The ultimate goal of complete radar control for all training missions -- takeoff to touchdown -- is expected to become a reality in the 1973-1974 time frame.

Elaborate operating procedures support the complete radar control concept at all UPT bases. The procedures are designed to accommodate the heavy flying schedule and to provide an orderly flow of traffic which is cleared of conflicts and allows consistent utilization of approach and runway facilities. The extreme performance differences between the training vehicles and the need to plan out conflicts increases the complexity of these already complex procedures.

The utilization rate of the UPT airspace is extremely high. Current UPT operations are conducted from dawn to dusk under a smooth flow concept of launching two training aircraft -- one T-37 and one T-38 -- every three minutes. In addition, training operations are frequently conducted into the night to accomplish current training requirements.

The student's training schedule in Current UPT is oriented toward a conventional five-day week, with limited training on weekends. Currently, UPT bases must schedule weekend training in response to makeup requirements after periods of bad weather. In addition, weekend time is used to conduct extended navigation training; the instructor and student take off on Friday afternoon and return to the home base on Sunday.

The current duration of Undergraduate Pilot Training is 47 weeks for academic, ground trainer, and flying requirements, plus one week of processing in at the beginning of the course. The rate of training is based on acquiring an average flying activity rate of 1.15 hours per training day.

All USAF students in the UPT program are officers and college graduates with the exception of a small number of students who are previously-rated navigators and who may or may not be college graduates. The attrition rate that is used for planning in the current UPT program is approximately 27 percent. This is the figure which is published in the Programmed Flying Training (PFT) document. The actual attrition rates, as experienced, fall very close to the planning percentages. Attrition rates are based on actual student performances which are measured, throughout the current UPT program, by a combination of daily performance assessments and periodic check flights. The control document for course training -- the syllabus of instruction -- specifies required skill levels which are based on the number of flying hours and the phase of training.

All UPT wings are organized using the dual deputy organizational structure. The deputy commander for operations (DCO) is the focal position in control of the daily conduct of training. Under his command are the flying training squadrons and the student squadron. The latter functions as a composite academic, military training, and administrative unit. All other deputies to the wing commander support the training effort in the areas of material, facilities, and medical requirements.

The location of the current UPT bases is shown on Figure 2. All bases shown are UPT bases except Randolph AFB which is the Training Command Headquarters and also the location for Pilot Instructor Training. Table I shows more details on the size and location of these bases.

The manning levels of an average UPT base is shown in Table II. Total manning for UPT training is shown in Table III. All of these data are presented to show the magnitude of effort devoted to Undergraduate Pilot Training.

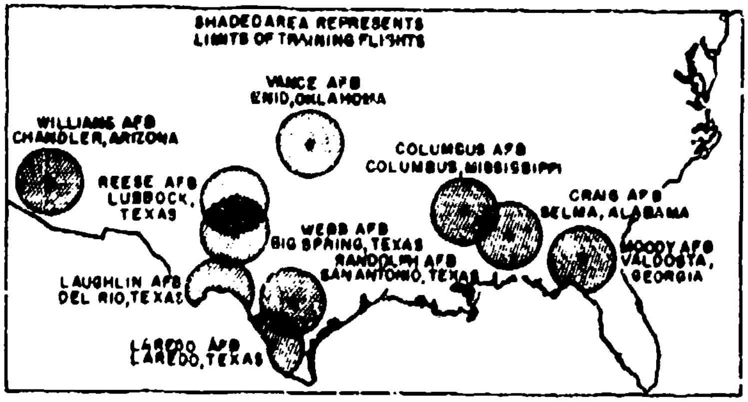


Figure 2. Undergraduate Pilot Training Bases

TABLE I

ACREAGE AND LOCATION OF UPT BASES

Pilot Training Wing	Name of AFB	State	AFB Area, acres	Altitude, feet	Closest City	Distance, miles	Direction
3500	Reese	Texas	2758	3338	Lubbock	12	W
3510	†Randolph	Texas	2622	761	San Antonio	16	ENE
3525	Williams	Ariz.	3857	1385	Chandler Mesa	10 16	E SE
3550	Moody	Ga.	5519	233	Valdosta	10	NNE
3560	Webb	Texas	2453	2561	Big Spring	3	SW
3575	Vance	Okla.	3056	1307	Enid	4	S
3615	Craig	Ala.	2493	176	Selma	5	SE
3640	Laredo	Texas	2095	508	Laredo	3	NE
3646	Laughlin	Texas	4470	1000	Del Rio	8	W
3650	Columbus	Miss.	5076	214	Columbus	9	N

† Headquarters ATC, and Pilot Instructor Training

TABLE II

TRAINING ORGANIZATION MANNING LEVELS
Average UPT Base

Training Organization	Manning Levels (2nd Qtr 70)		
	Officers	Airmen	Civilians
3500th Pilot Training Wg Hq	43	162	46
35th Air Base Group	35	340	354
3500th Field Maintenance Sq	5	312	165
3500th Hospital	42	100	36
3500th Organizational Maint Sq	5	382	6
3500th Pilot Training Sq	125	6	1
3500th Supply Squadron	7	188	78
3501th Pilot Training Squadron	111	4	1
3501th Student Squadron	31	14	9
Total for Wing	404	1508	696

TABLE III

1970 PERSONNEL COMPLEMENT AT UPT BASES

Pilot Training Wing	State	Airfield	Personnel					Family Housing Units	Total Acres
			Military	Civilian	Total	PCS Students	TDY Students		
3500	Texas	Reese	2029	736	2765	435	60	419	2758
3510	Texas	†Randolph	5106	2907	8013	364	78	1019	2622
3525	Ariz.	Williams	2801	761	3562	479	128	609	3857
3550	Ga.	Moody	1837	574	2411	398	53	106	5519
3560	Texas	Webb	2006	783	2789	404	54	465	2453
3575	Okla.	Vance	736	140	876	481	65	230	3056
3615	Ala.	Craig	1688	580	2268	352	47	326	2493
3640	Texas	Laredo	1992	546	2583	429	58	26	2095
3646	Texas	Laughlin	2184	654	2838	437	59	503	4470
3650	Miss.	Columbus	2354	398	2752	350	47	826	5076

† Headquarters ATC, and Pilot Instructor Training

In summary, the Undergraduate Pilot Training program in the Air Force represents a tremendous investment in resources and manpower. It is a well organized and efficient operation which at the present time produces capable pilots ready for mission qualification in front line aircraft.

TRAINING REQUIREMENTS ANALYSIS (APPENDIX C)

This subsection presents the methodology and results of the analyses required to develop operational mission requirements for the 1975-1990 time period, and to translate these into training requirements for Future Undergraduate Pilot Training.

The first step in this process was to select, from the 1975 to 1990 force structure, representative aircraft and missions for which task analyses were to be performed. This step was necessary in view of the fact that an adequate task analysis for each of the aircraft in the 1975-1990 force structure would have produced voluminous data, much of it redundant.

The second step in this process was to project the system characteristics of advanced and future operational aircraft, in order to provide the mission and task analyses with a basis for describing functions and tasks for aircraft not yet operational.

The third step was to analyze the missions for the selected aircraft in order to select and define the mission phases, segments, and functions to be considered by the task analysts.

Fourth, a task analysis was performed to identify and analyze the pilot tasks for each mission phase, segment, and function identified in the Mission Analyses.

The fifth step in this process was to develop and implement commonality analysis techniques in order to determine which of the pilot tasks identified are suffuciently common to warrant incorporation of training for these tasks in Future UPT curricula.

The sixth and last step in the identification and selection of candidate training requirements utilized the pilot tasks and functions identified by the commonality analysis and combined these data with an analysis of current UPT and combat crew training syllabi.

Representative Future Operational Aircraft Selection

The definition of future pilot training requirements (1975-1990) required examination of all projected Air Force missions and key characteristics of the aircraft that will perform these missions. This subsection identifies the aircraft examined and selected for the mission and the pilot functional and task analyses. The process for classifying the aircraft by missions and capability is presented along with the selected list of candidate aircraft.

The aircraft considered in the study are listed in Table IV. This listing of aircraft was derived from the Air Force Plan.

A total of 19 aircraft were selected for inclusion in the analysis since their capabilities adequately represented the mission spectrum forecast for the Air Force in the 1975-1990 time period.

A procedure was used to examine the aircraft in each mission category for similarity of pilot functions necessary to perform in a given mission category. The range of functions was selected to best represent each mission category, and one or more aircraft were then selected as representative for these range of functions.

TABLE IV

AIRCRAFT CONSIDERED IN FUTURE UPT MISSION ANALYSIS

Mission Category	Operational Aircraft	Advanced Aircraft	Future Aircraft
Air Superiority	$\boxed{\text{F-4E}}$	$\boxed{\text{F-15}}$	$\boxed{\text{VTOL Fighter}}$
Close Air Support	F-4D/ $\boxed{\text{A-7D}}$	$\boxed{\text{A-X}}$	$\boxed{\text{Advanced CAS Aircraft}}$ †
Interdiction	$\boxed{\text{F-111A}}$/D		All-Weather-Night Attack Fighter
Interception	$\boxed{\text{F-106A}}$		$\boxed{\text{AMI}}$, Hypersonic Defense System
Reconnaissance	$\boxed{\text{RF-4C}}$		
Strategic Bombing	B-52G/ $\boxed{\text{H}}$ $\boxed{\text{FB-111}}$	$\boxed{\text{B-1A}}$	Hypersonic Strategic System
FAC	$\boxed{\text{OV-10A}}$		FAC-X
Assault Transport	$\boxed{\text{C-130E}}$ C-7 C-123K	$\boxed{\text{LIT}}$	MIT Combined Supporting Aircraft ATEWS
Intertheater Transport	$\boxed{\text{C-5A}}$ C-141A		SST, ABMIS AWACS, SSWLS Advanced Log Transport
Refueling	$\boxed{\text{KC-135A}}$		KC-X
Rescue	$\boxed{\text{HH-53C}}$ HH-43B		Advanced Rescue System Advanced Local Base Recovery System

$\boxed{}$ Selected for analysis

† Advanced CAS. Only the all-weather attack segment was examined.

---

*The acronyms used in Table IV are identified as follows:

- CAS - Close Air Support
- AMI - Advanced Manned Interceptor
- MIT - Medium Intratheater Transport
- ATEWS - Airborne ballistic missile intercept
- ABMIS - Airborne Missile Interceptor System
- SSWLS - Standoff Strategic Weapon Launcher System

A task analysis was performed on ten representative aircraft included in the study. The task analysis for each aircraft was performed in accordance with the mission phases, segments, and functions which were determined on the basis of the mission objectives of the aircraft.

Field validation of the task analyses for the ten aircraft shown below was accomplished at the base indicated.

1.	B-52H	Castle Air Force Base
2.	C-130E	Little Rock Air Force Base
3.	RF-4C	Shaw Air Force Base
4.	C-5A	Altus Air Force Base
5.	F-106	Tyndall Air Force Base
6.	F-111A	Nellis Air Force Base
7.	OV-10A	Eglin Air Force Base
8.	A-7D	Luke Air Force Base
9.	F-4E	George Air Force Base
10.	HH-53C	Eglin Air Force Base

Additionally, a functional analysis (less detailed than a task analysis) was performed on the following advanced aircraft:

1. VTOL Fighter
2. F-15
3. AX
4. Advanced CAS Aircraft (all-weather attack segment only)
5. AMI (Advanced Manned Interceptor)
6. FB-111
7. B-1A
8. LIT (Light Intra-Theater Transport)
9. KC-135.

All task and functional analysis results were reviewed by representatives of each of the major air commands working on the Mission Analysis.

Methodology for Deriving Training Requirements

The commonality of a pilot task for a given operational time base is a function of the projected percent of graduates coming directly from UPT to CCT who will be assigned to operational aircraft in which the task is performed. In practice, the projected percent of all pilots who will be newly assigned to aircraft in which the task is performed had to be used due to the unavailability of separate UPT assignment projections. The number of newly assigned pilots for a given aircraft in a given operational time base consists of newly assigned CCT graduates who entered directly from UPT, CCT graduates who entered from previous operational assignments, and pilots transitioning directly from other operational aircraft.

Task commonality analysis necessarily entails task similarity analysis to determine whether or not the behavior required to perform the task is sufficiently similar across aircraft to warrant its being considered a single task for training purposes.

It was initially assumed that a single commonality analysis based on all operational aircraft would be sufficient for the purpose of developing curriculum content for alternative Future UPT systems. It was subsequently determined that a separate commonality analysis would be required for each specialized UPT graduate type for which a specialized system design was to be considered. If, for example, a highly specialized Future UPT training phase is designed to produce a graduating specialist whose subsequent CCT training and first operational assignment will be in air superiority type fighter aircraft, the task commonality analysis for that design must be based only on the pilot tasks performed in a set of air superiority operational aircraft. Similarly, a separate analysis could be conducted using the representative aircraft data to determine pilot tasks which are common to any specialized mission area. The volume of data limited the practical number of separate commonality studies necessary to support alternative Future UPT system options to the following:

Analysis	CCT/Operational Assignment Aircraft
Identified common pilot tasks performed in nearly all operational aircraft cockpits	All 19 representative aircraft
Identified common pilot tasks performed in most operational aircraft cockpits	All 19 representative aircraft
Identified common pilot tasks performed in air-to-air, air-to-ground, reconnaissance, and FAC mission aircraft cockpits	F-4E, F-15, F-106, AMI, VTOL, Fighter, A-7D, AX, ADV CAS, F-111A, OV-10A, RF-4C
Identified common pilot tasks performed in air superiority and intercept mission aircraft cockpits	F-4E, F-15, F-106, AMI, VTOL, Fighter
Identified common pilot tasks performed in close air support, interdiction, FAC, 2nd Reconnaissance mission aircraft cockpits	A-7D, AX, ADV CAS, F-111A, OV-10A, RF-4C
Identified common pilot tasks performed in strategic bombing, transport, refueling, and rescue mission aircraft cockpits	B-52H, FB-111, B-1A, C-130E, C-5A, KC-135A, LIT, HH-53C
Identified common pilot tasks performed in strategic bomber mission aircraft cockpits	B-52H, FB-111, B-1A
Identified common pilot tasks performed in assault and intertheatre transport, refueling, and rescue mission aircraft cockpit	C-130E, C-5A, KC-135A, LIT, HH-53C

It is true that the quantitative value of the commonality criterion has no intrinsic or absolute meaning regardless of the way in which commonality is defined. Alternative values of the criterion are correct or incorrect only to the extent that they result in curricula which are empirically determined to be superior or inferior on the basis of some independent criterion, such as pilot quality.

In the absence of empirical validation, the relative merit of specific values of the criterion can only be stated in terms of the difference between an identified set of candidate training requirements, and some reference set of training requirements. The reference training requirements are those included in the current UPT curriculum.

The assumption underlying task commonality is that any task which is as common or more common than tasks trained in current UPT should be considered as a candidate for Future Undergraduate Pilot Training. The effect of this assumption depends on the degree of specialization under consideration. For example, in the commonality analysis for a fighter-specialized training phase, where only fighter aircraft were included in the analysis, it was determined that ground attack tactics are more common than formation, which is taught in current Undergraduate Pilot Training.

Under the adopted commonality analysis criteria, a task identified by a criterion value of 75 to 100 percent commonality (tasks common to 75 to 100 percent of the total sample) was allocated to the Primary Phase of Future UPT regardless of whether a generalized single-track or specialized two or four track system was utilized. A task identified by a criterion value of 40 to 75 percent was allocated to the Basic Phase of Future Undergraduate Pilot Training. When generalized systems were considered the 40 to 75 percent criterion was applied to all aircraft in the sample. When specialized systems were considered, the 40 to 75 percent criterion was applied to aircraft in either the fighter, attack, interceptor, reconnaissance (FAIR) sample or aircraft in the tanker, transport, bomber (TTB) sample. All other tasks were rejected for Future Undergraduate Pilot Training.

It will be noted that no common pilot tasks were identified as leading to potential training requirements for VTOL fighters, VTOL transports, or helicopters. This is due to the projected low number of new pilots to be assigned cockpit positions in these aircraft in the selected operational time base. Under these conditions a low weighting factor is assigned, and the tasks are rejected. Similarly, the projected low number of pilots to be assigned cockpit positions in variable wing sweep aircraft caused common tasks associated with this aircraft characteristic to be rejected.

Future Training Requirements

A comparison of the commonality analysis and current syllabus analysis resulted in the identification of 30 standardized categories of training. These training requirement categories were selected as the candidate Future UPT training requirements for the remainder of the study. All of the viable UPT training requirements that could be identified by other methods, i.e., needs of the operating commands data and review of non-USAF pilot training systems, were included in these 30-training requirements categories. Those that were rejected were either 1) training requirements such as "weapon delivery," which were identified in a more specific and, thus, more accurate and useful form by one or more of the 30 categories; or 2) specific training requirements which could be clearly rejected as candidates for Future UPT on the basis of some other criterion such as use of highly automated or mission-specific avionics which required negligible training time to learn in order to operate the subsystem in Combat Crew Training.

The 30 training requirements listed in Table V include those 20 that are currently taught in UPT and confirmed by the commonality analysis. The remaining 10 training requirements listed are those identified by the task and commonality analyses which are not included in the current UPT program.

TABLE V

FUTURE TRAINING REQUIREMENTS

Training Requirement Allocation		Primary	Gen Basic	FAIR Basic	TTB Basic
1.	Ground Operations	X	X	X	X
2.	Pre-Takeoff Taxi	X	X	X	X
3.	Takeoff	X	X	X	X
4.	Formation Takeoff		X	X	
5.	Climb/Level Off	X	X	X	X
6.	Descent/Approach	X	X	X	X
7.	Landing	X	X	X	X
8.	Post Landing Taxi	X	X	X	X
9.	Basic Control	X	X	X	X
10.	Precision Control	X	X	X	X
11.	Stall Recognition and Recovery	X	X	X	X
12.	Aerobatics	X	X	X	
13.	Unusual Attitude Recovery	X	X	X	X
14.	Pilotage/Dead Reckoning	X	X	X	X
15.	High/Low Alt. Nav. Man.	X	X	X	X
16.	Close Formation	X	X	X	X
17.	Trail Formation		X	X	X
18.	Communications	X	X	X	X
19.	Spin Recognition and Prevention	X			
20.	Emergency Procedures	X	X	X	X
†21.	Tactical Formation		X	X	
†22.	Basic Fighter Maneuvers			X	
†23.	Air-to-Ground-Fundamentals			X	
†24.	Air Drop Fundamentals				X
†25.	Radar Navigation		X	X	X
†26.	Crew Coordination				X
†27.	Formation Landing		X	X	
†28.	Low-Level Visual Navigation		X	X	X
†29.	Collision Avoidance	X	X	X	X
†30.	Decision Making	X	X	X	X

†New Requirements

These new training requirements combined with the current training requirements provide an interesting distribution of alternatives for Future UPT systems and shed considerable light on the issue of generalized versus specialized type UPT training. Actually, the distribution of training requirements removes the generalized versus specialized issue entirely. The critical decision centers on the depth of training envisioned for Future UPT in terms of the number of training requirements specified. Using the commonality criteria utilized in identifying the training requirements, three fundamental groupings result:

- A Future UPT based on 20 training requirements which is basically today's UPT program
- A Future UPT based on 26 training requirements which expands the scope of UPT by today's standards
- A Future UPT based on 30 training requirements which further expands the scope of UPT by today's standard.

The first and second alternatives provide for only a generalized training approach because with the 20 or 26 training requirements specialization is unnecessary and uneconomical. The third alternative provides for a specialized training approach because with 30 training requirements, a generalized approach is uneconomical and violates the commonality analysis rationale. The determination of the training requirements and their grouping into the three alternatives was a critical process since it provided the framework within which the remaining analyses would be conducted.

Course Training Standard

The final part of the training requirements analysis concerned the management process necessary to ensure a continuing review of the training requirements and to provide a timely means for implementing changes. As such, this process represents an agreement between the pilot trainers and the pilot users. It can only exist in a viable manner if all parties to the agreement understand the communicative process necessary to effect required changes.

The findings of the Mission Analysis support the need for increased communication between the trainers and the users by a more specific process than is in effect today.

EXTERNAL INFLUENCES (APPENDIX D)

Five important influences were identified and analyzed to determine their impact on Future Undergraduate Pilot Training. Four influences are concerned with the number and type of candidates needed for pilot training. The fifth influence concerns the airspace for conducting pilot training.

Future UPT Production Rates

Historical Air Force and total UPT production rates (Air Force plus Air National Guard, Air Force Reserves, Military Assistance Programs, Marines, and NASA) for 1962 through 1971, and programmed production rates for 1972 and 1973, are listed in Table VI.

TABLE VI

UPT PRODUCTION RATES

Fiscal Year	USAF	Air National Guard	Military Assistance Program	Air Force Reserves	Marines	NASA	Total
HISTORICAL							
1962	1295	62	214				1575
1963	1433	58	209				1700
1964	1675	115	130				1920
1965	1992	126	134				2252
1966	1969	177	118				2264
1967	2702	133	158		3		2996
1968	3084	157	65		15		3321
1969	3216	142	75		118	7	3558
1970	3521	156	123		167	2	3969
1971	3913	145	120		225		4411
PROGRAMMED							
1972	3925	145	300	55	0		4425
1973	2875	280	360	150	0		3665

NOTE: These figures do not include Undergraduate Helicopter Training rates or UPT training conducted for the German Air Force

Information received from Headquarters USAF, as of 14 September 1971, specified the FY 1973 production rate of 2,875 U.S. Air Force pilots and 3665 total pilots. Indications are that the fiscal year 1973 production rate may eventually be even lower. At this writing, Headquarters USAF has not finalized the forecast of production rates beyond fiscal year 1973.

The uncertain climate existing today over UPT production makes meaningful predictions out to 1990 somewhat tenuous. Furthermore, since USAF furnished force structures did not project beyond 1981, all estimates beyond this date must take into account both political and technical developments that might influence the production schedule for Future Undergraduate Pilot Training.

The force structure used to determine the production rate requirements was developed by two independent contracted studies. In addition, the USAF Personnel Plan (TOPLINE) was used to determine the total number of pilots required to fill the operational, supervisory, instructor, pipeline, and supplemental rated force.

The "TOPLINE" Air Force UPT production rates are listed in Table VII and reflect the minimum number of Air Force UPT graduates deemed necessary to sustain the variable force structures recommended by TOPLINE. The TOPLINE force structure is that goal established by the USAF for the future and may not necessarily be reached until fiscal year 1982. The result of this, analysis established that a total production level of 3665 is an adequate number to support the force projection out to 1990. All Future UPT system options were designed around this level of production for comparative purposes. In order to account for any fluctuations in Future UPT, the evaluation of the system options provided for a sensitivity analysis of ±500 in the level of production. The plus 500 figure supports the current USAF surge planning. The minus 500 figure accounts for the possible further drawdown in UPT production.

TABLE VII

UPT PRODUCTION RATES

"TOPLINE"

Range	Objective Force	Total Pilots	A.F. UPT Production	Total UPT Production
83 - 92,000 (Low)	80,800	31,218	2,660	3,325
92 - 104,000	91,200	34,214	2,768	3,433
104 - 116,000 (Mean)	102,900	37,481	3,099	3,764
116 - 129,000	114,200	40,581	3,335	4,000
129 - 143,000 (High)	126,800	44,181	3,519	4,183

Active USAF Officer Force exclusive of doctors and dentists

Objective officer force structure for line and JAG only

USAF only, plus 125 UHT graduates. Figures represent the minimum rate necessary to support the total pilot force.

Total UPT production rate includes USAF/ANG/MAP/AFRES/etc. Does not include 125 UHT graduates.

Graduate Assign[illegible]ution

Forecast graduate assignment distributions [illegible]eeded in the analysis to provide a design point for those future training systems option that specify a specialized approach to UPT training (and incorporate 3D training requirements).

The projected UPT graduate assignment distribution was developed from the future force structure projections previously described. These estimates were compared with historical UPT graduate assignment distributions to determine the degree of fluctuation that might be expected.

Assignment distributions were divided into seven categories according to missions and then into two groups according to commonality of pilot task. The seven categories were fighter, attack, interceptor, reconnaissance, tanker, transport (tactical and strategic), and bomber. The two groupings were fighter, attack, interceptor and reconnaissance (designated by the acronym FAIR) and tanker, transport, and bomber (designated by the acronym TTB).

Total operational force pilot requirements were determined by analysis of the force structure projections and the latest crew size and aircrew ratios listed in AFM 172-3, "USAF Cost and Planning Factors." Crew requirements for aircraft not listed in AFM 172-3 were assumed to be the same as similar aircraft presently in the inventory. The result of these projections along with historical UPT assignments is shown in Figure 3 for FAIR (32 percent); the remaining 68 percent is for the TTB distribution. It is significant to note that in no case did any projected force structure assignment distribution vary from the average more than eight percent of the total pilot assignment.

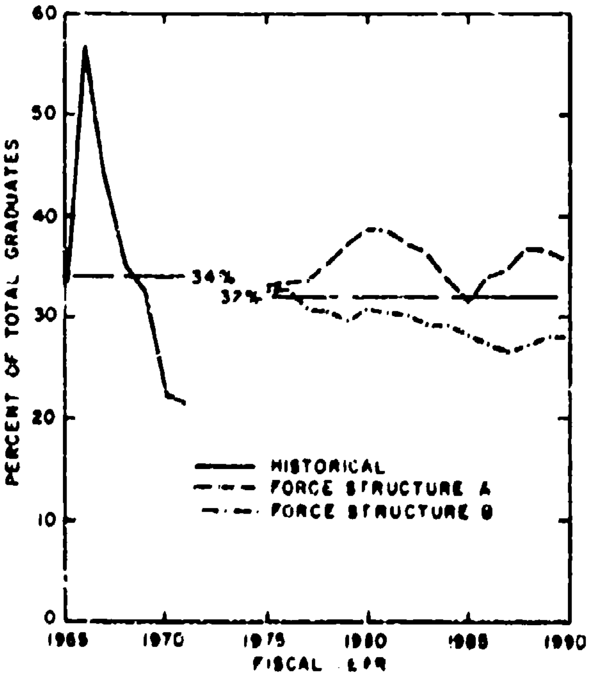


Figure 3. UPT Graduate Assignments: Fighter/Attack/Interceptor/Reconnaissance (FAIR)

Based on this analysis, a distribution of 40 percent FAIR and 60 percent TTB was selected as the design point for the system options incorporating 30 training requirements. This design point takes into account the eight percent variation in the actual distribution of 32 percent FAIR and 68 percent Tanker, Transport, Bomber.

Student Pool

The number of young men potentially available for pilot training determines, in large measure, some of the necessary characteristics of the training program and the stringency of the selection standards that can be applied. The amount of manipulation possible with the future student pool is limited by the fact that all potential pilot training candidates for the 1975-1990 time period had been born by June 1970. Furthermore, the long lead time associated with candidate procurement programs has resulted in no data being available on the impact of recent changes in the selective service system and the likelihood of an all volunteer force.

It was necessary to examine the source population in detail to determine if current selection standards could be maintained into the 1990s and, if not, to examine alternative selection standards that could be maintained. Evaluation of the 1975-1990 UPT source population was accomplished by 1) determining the total possible number of males between the ages of 20 and 26 for each year during the time span, 2) estimating the total number of these, based on Selective Service deferment percentages, who could volunteer for UPT, and 3) determining the numbers of these "potential volunteers" expected to pass minimum physical, mental, and moral standards (via estimates from Armed Forces Examining and Entrance Stations (AFEES) records). These analyses provide an estimate, by year, of the total pool of minimally qualified men with no reason for deferment from active duty in the Armed Forces.

Pilot selection standards are greater than minimums required for entry into the Armed Forces and, thus, reduce the size of the service-qualified pool by a given percentage. These percentages for various vision and educational standards were applied to the pool (these two standards are the ones which disqualify the greatest number of potential UPT applicants). The fact that UPT is a volunteer program further reduces the number of available applicants since not all qualified men wish to enter the program. Factors affecting the number of volunteers were considered and the yearly number of qualified UPT volunteers during 1975-1990 was estimated.

Analysis of the 1975-1990 source population is based on the assumption that UPT candidates will continue to be male volunteers between 20.5 and 26.5 years of age.

The projections of the future manpower pool as shown in Table VIII are based on recorded live male births through 1966 and projected live births to 1970. The Bureau of the Census, Population Division, has made projections of the population to 1990 based on the 1960 census. They have also made estimates of the percentage of men who will complete college during the 1975-1990 time span. These estimates were in substantial agreement with the historical data of the previous 22 years and are considered valid. Estimates were also provided on the number who will have completed two years of college during each year from 1975-1990. The estimated percentage of physical rejections (mainly the failure to meet visual standards) was applied to a number of men completing college during the time period. The manpower pool of men with four-year college degrees and 20/20 vision will number between 380,000 and 400,000 annually during 1975 through 1990. These numbers are considered

TABLE VIII

MANPOWER POOL, 20.5-26.5 YEAR-OLD MALES, 1975 THROUGH 1990
(In Thousands)

Year	A	B	C	D	E	F	G
1975	11,875	12,126	12,103	12,138	2,682	2,307	3,350
1976	12,109	12,375	12,352	12,390	2,738	2,355	3,420
1977	12,361	12,633	12,609	12,644	2,794	2,403	3,490
1978	12,617	12,895	12,270	12,905	2,852	2,453	3,563
1979	12,834	13,116	13,091	13,126	2,901	2,495	3,623
1980	12,961	13,246	13,221	13,256	2,930	2,520	3,659
1981	12,998	13,284	13,259	13,294	2,938	2,527	3,669
1982	13,095	13,383	13,358	13,393	2,960	2,546	3,696
1983	13,048	13,335	13,310	13,345	2,949	2,536	3,683
1984	12,926	13,210	13,185	13,220	2,922	2,513	3,649
1985	12,723	13,003	13,978	13,013	2,876	2,473	3,592
1986	12,419	12,692	12,668	12,703	2,807	2,414	3,506
1987	12,047	12,312	12,289	12,324	2,724	2,343	3,401
1988	11,011	11,253	11,232	11,267	2,724	2,141	3,110
1989	11,189	11,435	11,413	11,448	2,530	2,176	3,160
1990	10,716	10,952	10,931	10,966	2,423	2,084	3,027

adequate to support future UPT production requirements. However, the effects of an all volunteer force with the attendant elimination of the draft is an unknown quantity in this assessment. In the past, there has always been a high correlation between the level of draft inductions and the number of male students entering college. Furthermore, estimates as high as 60 percent have been made on the number of persons entering voluntary military programs such as UPT to avoid the draft. This possibility, combined with a general dissatisfaction with the National Military Policy (like that demonstrated in the late 1960s) could make future recruitment of qualified UPT applicants difficult.

Student Screening and Selection

The U.S. Air Force future aircraft mix and research on trainee and pilot performance, selection, and training attrition were analyzed to derive selection criteria for the future UPT program. The general categories consist of physiological, intellectual, perceptual motor, emotional, and motivational requirements. Detailed analyses were performed on the first three of these. The selection methods necessary to measure these variables should consist of 1) a comprehensive medical examination, part of which is given in actual or simulated flying environments, 2) tests of memory, attention, and communication as well as verbal and quantitative skills, 3) perceptual-motor tests and/or comparable behavioral work samples, 4) measures of emotional stability and stress resistance, and 5) measures of interest in flying, attitudes toward the military, and career intent.

An important factor in the development of a force of capable pilots is the choice of inputs to the training system; i.e., the selection of personnel who will be able to acquire and apply the skills taught. The purpose for selection among applicants to a training program is to produce qualified graduates in the shortest time and at the lowest cost. This may be accomplished by the early identification of those with the appropriate degree of

NOTES FOR TABLE VIII

A	=	Male live births in previous 20.5 to 26.5 years (U.S., Alaska, Hawaii)
B	=	Male live births adjusted to include all sources of population
C	=	Number of live births, male, surviving to age 20 (99.81%)
D	=	Total manpower pool adjusted for immigration
E	=	Possible volunteers (based on Selective Service deferments) excluding students (22%)
F	=	Numbers expected to pass minimum standards for military service excluding students (86%); POTENTIAL UPT CANDIDATE POOL
G	=	Numbers expected to pass minimum standards, including students (27.6% of column D)

relevant attributes and by the elimination of potential failures. The selection process may vary in approach from a complete acceptance of "natural selection," wherein selection is by attrition in the program (those persons who fail obviously were not qualified) to a pretraining selection process so appropriate to the training that there is no attrition. The selection process resulting from this study is designed to screen out potential failures at their initial point of contact with the system, identify at some point prior to entry into UPT those with a high probability of success as a student and operational pilot, and to permit "natural selection" for those attributes which, at present, are best determined by exposure to flying.

Theoretically, selection reduces the attrition rate during training and can result in a considerable cost savings, depending upon the selection/training cost ratio. Becaus volunteer programs, such as UPT, must be more attractive to the potential applicant than other possible choices, the use of the training program itself as the selection device (with no entrance requirements) has a superficial appeal. The use of attrition from training as the means of selecting qualified pilots does not eliminate selection; it merely transfers it to already burdened training personnel. Additionally, the elimination of pre-entry selection probably would require a change in status of the individual student; i.e., enlistment into the reserve or regular forces, and would add financial responsibility to other direct costs of the program. Some form of selection appears necessary, if only to reduce the costs attendant with waiting while attrition reduces the number of trainees.

Selection criteria define those attributes which characterize successful USAF pilots and were derived from the forecast pilot capability requirements, criteria which have been established in UPT and other training systems, and from background data on the selection problem. Selection criteria, thus, reflect the attributes an applicant must possess in order to complete UPT and to become an operational pilot. Selection standards define the degree to which these attributes must be present.

A review of the current student screening process was accomplished to determine its applicability to Future Undergraduate Pilot Training. Current attrition by source and cause was examined to identify those areas of the current system that warrant change, or areas to be addressed with an alternative system. A review of current and projected tests was accomplished to determine their applicability to the current system, and to determine the characteristics of an alternative system. Finally, a cost break-even analysis was made between the current and alternative system to determine the cost effectiveness of the alternative system.

The current process, whereby men are selected for UPT, may be considered in three parts: 1) selection for a program leading to a commission, 2) the selection which occurs during that program (attrition) and before the commission is tendered, and 3) selection for UPT from among commissioned officers. An applicant cannot volunteer directly for UPT; he must first meet the criteria and standards imposed by the commissioning institution and these vary considerably. For example, the selection criteria for entry into the Air Force Academy includes intellectual attainment in competitive examinations among Air Force personnel, recommendation by a U.S. Senator, or the military activities of the applicant's father; i.e., the sons of Congressional Medal of Honor winners or of those killed in action. None of these criteria are applicable to selection for Officer Training School (OTS) or Reserve Officers Training Corps (ROTC) which likewise lead to a commission. Regardless of the source of commission, all Air Force officers have met the criterion of educational attainment, as evidenced by the award of a four-year college degree, before they were commissioned. Prior to entry into UPT, all candidates will have taken and passed the Air Force Officers Qualification Test (AFOQT) and a Flying Class I medical examination. All candidates for UPT have volunteered for the program.

Current criteria for entry into UPT may be summarized as follows:

- Physical. Excellent physical condition as evidenced by the passing of a Flying Class I physical examination, including 20/20 vision

- Mental. No disqualifying personality defects, as evidenced by the acceptable Adaptability Rating for Military Aeronautics (ARMA)

- Intellectual. Ability to learn, as evidenced by the attainment of a four-year college degree

- Technical and Aptitude. Ability to pass those portions of the Air Force Officers Qualification Test (AFOQT) which relate to pilot attributes

- Military. Ability to function as an officer, as evidenced by the award of a commission in the Armed Forces

- Age. Between 20.5 and 26.5 years of age.

To appreciate the efficiency of this screening, we need to review the attrition rates experienced in Undergraduate Pilot Training. It is generally recognized that pilot training attrition rates are driven, in part, by relationship between trainee input and the systems output requirements a year later, and in part by the capability of the student pool. Thus, it is always important in discussing attrition rates to recognize that training programming and philosophy has at least some modest impact on attrition.

The total attrition rate for the period from FY 1965 through 1970 was 23.7 percent. It was at its lowest in 1965 with 16.1 percent and at its highest in 1970 with 27.2 percent. A trend of increasing attrition rate occurred in this period. Whether this trend will continue in FY 1971 is not known because the data were incomplete at the time of this analysis.

While total attrition rates may suffice to show that an attrition problem exists, a more useful set of data is one showing which students were attrited and for what reasons. Data for a prolonged period probably exist but were not in a readily usable form. Excellent data were available, however, for the period from 1965 through 1970. This is the period of greatest interest, in any event, because it expresses essentially the present attrition problem.

For the current pilot training system, information on reasons (or causes) of training attrition, differences in attrition by student source, and cost to the Air Force of attritions were available, and are of importance in estimating impact of changes in screening/selection procedures on future attrition. Attrition rates by cause, from 1965 through 1970, are presented in Figure 4. The percents given in the figure are the percent of the total input who attrited for the reason specified. The horizontal bands representing attritions are additive, summing to the total attrition rate in each year. Throughout the period covered by the figure, the largest group of attritions are accounted for by training deficiency. This cause accounts for roughly one-half to two-thirds of all attritions and has, on the whole, tended to increase during the period. Substantial proportions of the total, however, are also accounted for by self-initiated elimination (SIE), medical attrition, and manifestation of apprehension (MOA). Attritions not accounted for by any of these categories are combined in a heterogeneous group called Other, representing in most years less than one percent of the total. This group includes fatalities, if any, and attritions for various humanitarian reasons.

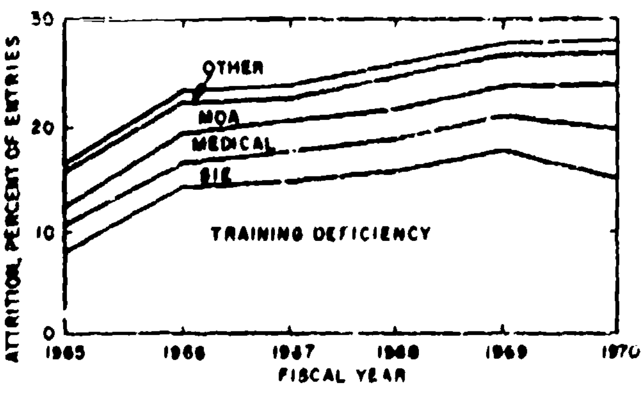


Figure 4. Pilot Training Attrition by Cause

Flying deficiency attritions result from a judgment by training personnel that a student, at a given point in the training program, lacks minimal competence either in academic work or in the translation of this into satisfactory performance in the aircraft. The data from 1966 through 1969 distinguish academic deficiency from flying deficiency as a cause of attrition. In that period there were a total of 2,040 flying deficiency attritions and only 133 academic attritions. Thus, only 6.1 percent of the training deficiencies were academic. This probably reflects a combination of the effectiveness of formal academic selection standards combined with use of the Air Force Officer Qualifying Test (AFOQT) academic (officer quality) composite as a selection standard.

In the fiscal years from 1966 through 1970 a total of 607 student pilots were attrited for medical reasons. This amounts to 12.9 percent of all eliminees during this period and 3.2 percent of all entrants. A large proportion of the medical attritions observed in fiscal year 1970 were for reasons in no way peculiar to pilots, at least not to pilots in the flying environment. The data show that 33 percent of the medical attritions occurred before the first flying hour in the T-41 and that 51 percent occurred by the tenth hour in the T-41. By the end of the T-37 phase 96 percent of medical attritions had occurred.

Some candidates for pilot training prove to be subject to manifestations of apprehension. The medical examination may not detect such candidates unless their anxiety states are chronic. Manifestation of apprehension is nevertheless a significant category of attrition. This category accounts for the loss of about three percent of students entered into training.

Self-Initiated Eliminations (SIE) from pilot training also occur with sufficient frequency to be of some concern. The recognized loss rate for this cause has ranged from two percent of entries in 1965 to five percent in 1970. During these years, SIEs have constituted from about nine to 19 percent of training losses. The SIE is probably one of the most difficult causes of training loss to identify clearly, since some students who wish to quit training may disguise their reason via deliberate failure. Thus, the loss rate for motivational causes is probably underestimated by the SIE category.

In summary, the most significant category of training attrition is that of flying deficiency elimination; academic failures constitute a relatively minor portion of training deficiency losses. Self-initiated eliminations, medical eliminations, and eliminations due to manifestations of apprehension each account for smaller but significant portions of training attritions: taken together, they have accounted for loss of from seven to thirteen percent of student input from 1965 through 1970 and for about half of the attritions during that period.

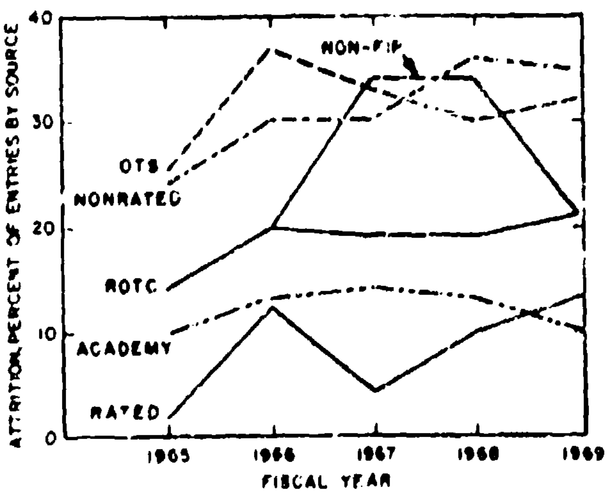


Figure 5. Pilot Training Attrition within Sources

One significant issue pertaining to attrition is the source from which attrited students come. Detailed data are available for the period FY 1965 through FY 1969 and are presented in Figure 5 and Table IX.

It is clear from the figures that the sources having the lowest attrition rates are the Academy and rated officers. The AFROTC group, on the whole, occupies an intermediate position, although for two of the years the Non-Flight Indoctrination Program segment of this group had a high rate. The two sources having the highest attrition rate are OTS and nonrated officers.

The importance of these data is to highlight the fact that as UPT production rates vary, the level of attrition will

TABLE IX

FISCAL YEAR 1969 UPT ATTRITION BY STUDENT SOURCE AND TRAINING PHASE

Student Source	Training Input		Training Attrition T-41	T-37	T-38	Total
AFROTC-Non-FIP*	2276	N	24	29	6	59
		%	8.7	10.5	2.2	21.4
AFROTC-FIP	1369	N	75	166	46	287
		%	5.5	12.1	3.4	21.0
OTS*	1969	N	335	253	41	629
		%	17.0	12.8	2.1	31.9
AF Academy	307	N	12	13	4	29
		%	3.9	4.2	1.3	9.4
Nonrated Officers*	226	N	37	36	8	81
		%	16.4	15.9	3.3	35.0
Rated Officers	85	N	5	4	3	12
		%	5.9	4.7	3.5	14.1
Total	4232	N	488	501	108	1097
		%	15.1	11.8	2.6	25.9

*These sources provide, essentially, no exposure to flight training or experience.

vary. At lower production rates, where Academy and AFROTC students make up the majority of the student population, the attrition can be expected to go down. Conversely, if production goes up and OTS students comprise a larger part of the student population, the attrition can be expected to increase. Finally, the significant aspect of attrition concerns cost and system capability.

The cost of training a student pilot to the point of attrition is very high and represents a dissipation of resources which could be better spent in other ways. This cost is not recoverable by the Air Force. Furthermore, students trained to attrition have an adverse effect on the capacity of the training program to produce qualified pilots, since they occupy places in the program which might have been occupied by successful students. This effect could be critical in a period of high requirements for pilots.

The cost of attrition in today's program is given in Figure 6. This shows the cost by training week associated with attrition. Based on these data and the attrition figures given previously, the average expenditure on a student who attrits in UPT training is approximately 10,000 dollars.

In summary of the present screening system, it can be stated that the major disadvantage centers around the inability to accommodate any type of extensive individual assessment.

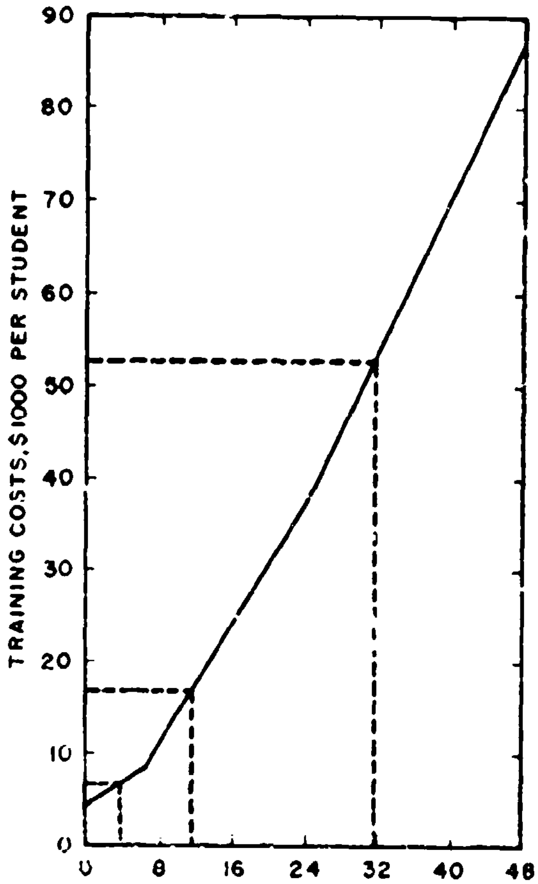


Figure 6. Cumulative Pilot Training Costs

Pending Changes -- Centralized T-41

During the early 1950s it was demonstrated quite effectively in two studies that a program of light plane training conducted just prior to entry into formal UPT reduces attrition in the early phases of formal UPT, and that there is no evidence that this difference is offset by later training attritions (in effect, this produces an overall lower attrition among those students who have had the light plane program). Outcomes of these studies have resulted in implementation of the variety of light-plane training programs in vogue in the Air Force officer training and commissioning programs. Air Force ROTC operates a flight instruction program (FIP), flight instruction is provided at the Air Force Academy, and finally, T-41 training constitutes the first phase of UPT as we know it today. Thus, in today's UPT many students who have had light plane indoctrination and screening as a part of their commissioning training program receive additional, and perhaps overlapping, training as a part of Undergraduate Pilot Training. Light plane training should be viewed as a student selection procedure rather than as an integral part of training. Attrition in the T-41 phase of UPT was analyzed in the various sources of student pilots. A most cost effective procedure for light plane selection of UPT students, which avoids duplication of assessment, should be possible. Under the present procedures, duplication does exist and this, in turn, tends to increase total system cost.

Centralized T-41 is in many respects a separate issue, based on a Hq USAF analysis which was turned over to Hq ATC for consideration. When seen as a candidate selection procedure, centralized T-41 reasonably fits into a selection center operation. It can serve as a stepping stone to a fully developed centralized selection center. It is assumed that centralized T-41 will be located in the vicinity of the Officer Training School. For convenience, a centralized selection center should be located in the same area.

Alternatives

The development of a screening/selection system involves examining the existing technology of behavioral prediction and applying those techniques which have relevance to the categories of attrition which have been important historically. Earlier causes of attrition were reviewed. The causes which appear to be amenable to systematic attack are discussed below.

Flying Deficiency

Training deficiency was identified as the most frequent cause of student attrition, accounting for about half of all attritions. Academic deficiency attritions constitute only a minor part of this, with most of these losses occurring because of flying deficiency.

Freedom from problems of training deficiency in UPT may be viewed as a consequence of ability to learn in a pilot training context. Students are expected to be deficient in flying skills until they have been taught. Deficiencies leading to attrition arise when what is taught is not learned with sufficient rapidity or thoroughness. When a student

falls behind his peers in his progression through the curriculum, he faces the likelihood of a deficiency elimination. Tests designed to assess learning ability for the knowledge and skills required of a pilot are, therefore, likely candidates. The aptitudes measured by the AFOQT are relevant to this learning, but they do not assess it directly. The inclusion of one or more measures of learning in a flying environment should be of appreciable value in improving selection.

Selection devices which permit direct assessment of learning in the pilot training context are no novelty. The light aircraft, such as the T-41, is one such device. Another device is the psychomotor test. For the most part, belief that tests of this type can be shown to be valid is well founded. These provide various measures of coordination and address the problem of training deficiency attrition. Among these tests, the ones most favored for inclusion in the Future UPT selection battery are those for which a body of data already exists on their relationship to pilot training and on which an active research program related to pilot training is in progress. So far as is known at this time, only two phychomotor tests meet both of these criteria.

Psychomotor testing in a pilot training context has a lengthy history. Some of the earliest selection devices were of this type, although they went largely unexploited. Two of the tests known as Complex Coordination and Two-Hand Coordination were used operationally during WW II and up to 1953.

The decision to abandon them was not made because of lack of validity but because they were difficult and expensive to maintain. The fairly recent developments of industry seemed to offer the possibility of building an apparatus which could be operated electronically. Accordingly, a prototype psychomotor testing station was designed and built under contract. Installation was completed late in 1970 at the Personnel Division of the Air Force Human Resources Laboratory, Lackland Air Force Base.

Thus far, two tests have been programmed. One is an updated version of the Complex Coordination tests. It involves manipulation of a stick and rudder bar to position at a fixed point with the stimuli presented on the screen. The other task is an updated Two-Hand Coordination test in which both hands are used to manipulate two sticks in performing a circular tracking task. Data have been collected on over 130 OTS students who were selected for pilot training. Most of these students subsequently entered pilot training, but sufficient time has not yet elapsed to permit any to graduate. Hence, the initial validation study of these two tasks has not been performed. These two tests are identified as candidates for future selection use.

Another device capable of flying proficiency assessment is a ground trainer device with low fidelity motion and a low quality visual scene. This device might be classified as a low fidelity simulator.

The Human Resources Laboratory's Flying Training Division at Williams AFB is currently conducting research into the utility of this type device -- a General Aviation Trainer (GAT)--as a predictor of success in Undergraduate Pilot Training. While their samples are small, results to date suggest that GAT instructor evaluations of student performance are about as valid for prediction of T-37 criteria as are T-41 (light plane screening) evaluations (both show modest correlations with pass/fail in T-37).

Training and assessment accomplished in a device like the GAT have a number of advantages when compared with similar training and evaluation in a light aircraft. One advantage is its economy (the GAT has a significant cost advantage over the light aircraft). Another advantage is the greater number of hours per month the GAT is available for use. Still another is safety. One of the greatest advantages is that an objective record of performance in the GAT can be obtained automatically as the device is being flown. This record is available for evaluation by both the student and instructor following the flight.

Subjective evaluations of attitude, judgment, safety, and air-sense, can still be made by the instructor as supplements to the objective record. A GAT type trainer merits consideration as a future selection device.

Motivational and Stress (MOA) Attritions ———

Self-initiated eliminations and elimination because of manifestations of apprehension both constitute significant segments of student pilot attritions. Moreover, there is suspicion that some students attrit from training for motivational factors which result in training deficiency elimination.

Many students are motivated by their misconceptions. They may believe they want to be pilots because they perceive the life of a pilot is filled with glamour or adventure. While a pilot's life may contain some of both, this is a poor basis for choosing a pilot career. One must like the activities which are the daily lot of most pilots most days. Measures designed primarily to combat attrition caused by manifestation of apprehension also have relevance here because under high motivation most individuals can endure severe stress. Failure to do so may result more from unwillingness than inability.

Prior familiarity with the art and science of flight, even if not as a pilot, can serve as a self-selection device. Students attracted to a pilot career, when the attraction exists in the presence of much realistic knowledge of what is involved, are not highly prone to attrition, especially for any of the reasons which might be described as motivational

Ongoing research by the Human Resources Laboratory is examining several promising approaches to pilot motivation development and measurement that may be applicable in UPT selection. Two of these, the "Attitude and Career Intent Survey and Motivation Engineering Study for Pilot Training" show possibilities and are identified as candidate approaches for future student selection.

Two candidate selection procedures involve miniature stress situations. One involves altitude training indoctrination. The altitude chamber has been demonstrated to be an effective indicator of manifest anxiety toward flying. The second one involves survival training. Survival school could be made both a training activity and a selection activity by placing it in the selection program. This would permit a full-scale assessment of response to genuine stress. Initially, it should be tried as a small scale experiment under the auspices of the selection center and later made a full-fledged part of selection only if the experimental results warrant. If survival school does become part of selection, it is important that the school continue to include several days of exposure to isolation and an inhospitable environment during which survival techniques can be practiced. If such an approach were adopted, it should occur after other, less expensive, selection assessments. This reversal in training sequence (prior to UPT) could have the advantage of early identification of those candidates with weak motivation.

Medical Losses ———

A significant number of students are lost from training for medical causes. It is expected that the major thrust against medical attrition may come from a more rigorous application of existing standards to the medical examination. This could be accomplished by giving a second medical examination at the centralized selection center.

It appears that substantial inroads on the medical attrition problem can be made by intensification of existing practices without recourse to exotic evaluations. Examination emphasis would be on the most common causes of medical disqualification. To it, however, could be added, later, such medical tests as the medical research programs in the Air Force might be able to justify for pilot candidates. Most such tests considered thus far are lacking in research support for inclusion in the medical examination. This is frequently because of very high correlations between pass and fail in UPT for tests already included.

Characteristics of the Future System

Future UPT selection proposals made here are tentative, pending validation prior to full implementation. The system would consist of separate screening and selection assessment phases. Screening would be, essentially, the procedures (Class I Physical Exam & AFOQT, etc.) in current usage.

In the selction phase the candidate would be carefully observed and evaluated over a period of approximately two weeks. Such assessment cannot be conducted successfully except at some centralized facility to which the candidate may be temporarily assigned. The major reason for this is the need for rigorous standardization in the application of assessment techniques. Table X outlines procedures that could be employed at the selection center, along with an estimation of candidate time required by each procedure. It is anticipated that, when operational, such centers should accommodate half again as many candidates as the number to be entered into training (thus allowing for a favorable selection ratio). During the experimental stage, all candidates assessed should be entered into training for purposes of system validation.

TABLE X

OUTLINE OF SELECTION CENTER OPERATIONS

	Subject Time, hours
Psychomotor Testing	3
Attitude and Career Intent Survey	3
General Aviation Trainer Instruction and Testing	20
Altitude Chamber	8
Indoctrination and Testing	30
Class I Physical	4
Total Time, hours	66

To the extent possible, there should be no long lapse of time between completion of selection and the beginning of UPT, because it is important that motivation built up in the orientation phase of selection should not be allowed to lapse.

Centralization of T-41 training and reversal of the Survival Training UPT sequence should be tried, evaluated, and implemented separately from the selection center experiment.

An independent experiment to assess utility of Survival Training given prior to UPT should be conducted using existing facilities, and should follow the existing curriculum.

The majority of procedures specified under a new selection system will require validation prior to operational implementation; this must, of necessity, be preceded by detailed development of selection center syllabi, schedules, and procedures. The psychomotor tests identified for use are already in process of being validated for pilot selection; data on student performance in UPT for samples tested on these devices should begin maturing at the end of calendar year 1971. Shortly thereafter, a decision about their utility should be possible. A year would be required for equipment procurement, and costs would be a function of the number of items of equipment required.

A desirable plan would be to consider implementation of these selection tests in the context of a selection center operation. Ideally, the total selection center concept would be tried out experimentally, validated, and then revised, as necessary, and implemented. During a validation period, it would be neither necessary nor desirable to operate a full center capable of processing all incoming pilot training candidates.

Once the experimental center begins operation, a two year lag would be involved for collection of full training data on the first year's subjects; during validation, experimental operation should continue to allow for cross validation. An additional six

months would be required for validation against training criteria. At that point, decisions about whether to go operational could be made. Full scale implementation would be possible as soon as the center could be expanded to full capability. This experimental stage would, thus, require a minimum of three-and-one-half to four years for full validation. An additional year would probably be required for center expansion. Thus, if a go-ahead were secured in early 1972, a fully implemented center would not be a reality until about 1976.

Center operation throughout its development and later operation should provide flexibility to periodically schedule small experimental modifications for validation and possible later system improvements.

Costs of a Selection System

Costs of the proposed alternative selection system are difficult to determine before validation tests of its various parts are completed and a determination can be made of those parts which should be applied. The selection system's "cost affectiveness" is a function of the extent to which it reduces attrition in UPT training.

Selection center validation costs can be based on a facility equipped and staffed to accept 16 candidates each week (with each candidate remaining at the facility for two weeks). When operational, the facility and staff would require expansion to accommodate perhaps six such 16-man groups each week (or an increase to six times validation size). The facilities required for validation are shown in Table XI.

TABLE XI

REQUIRED FACILITIES FOR SELECTION CENTER VALIDATION

Phase	Required Facilities
Phychomotor Testing	PDP-8 computer with one subject station (cost = ~25K). One enlisted operator. Air conditioned space for one 12 x 12 foot control room and one 12 x 12 foot test room.
Attitude and Career Intent Survey	One 16-man testing room and one administrator for three hours per week (could be psychomotor testor).
GAT Instruction and Testing	Two GAT-Is each in 20 x 20 foot room (air conditioned with a simple cyclorama). Two small briefing rooms. Staff to provide 320 hours per week of instruction (GAT and brief-debriefing). This assumes maximum utilization of the equipment.
Indoctrination	Adequate staff and visual aids to provide 20 hours per week of group instruction and assessment. Classroom to accommodate 16 candidates.
Class I Physical	Medical facility and staff adequate for 16 Class I physicals per week.
Altitude Chamber	Chamber and personnel sufficient for processing 16 candidates per week, including orientation and discussion.
All Phases	Housing and messing facilities for 32 candidates

The critical question about whether a selection center activity should be implemented hinges strongly on whether the center's operating costs could be offset by savings in UPT training cost resulting from reductions in attrition. Air Training Command estimates are that 16,000 dollars in training costs are expended on each student who attrits.

A five percent reduction in the current student attrition would result in a training cost saving of 1452 dollars per graduate; a ten percent reduction would save 2727 dollars per graduate; and a 15 percent reduction would save 3856 dollars per graduate.

If one assumes that one and one half times as many candidates must be assessed at the center as the number of desired UPT graduates, then maximum-per-candidate assessment costs cannot exceed $968 for a five-percent attrition reduction; $1818 for a ten percent reduction; or $2570 for a 15 percent reduction.

For survival training-UPT training sequence reversal to be cost effective, slightly less than a three-percent attrition reduction would be required.

The available evidence suggests that centralized T-41 would save 1.5 million dollars per year.

Conclusions

The attrition rate from UPT continues to be a problem despite its reduction from previous levels through the introduction of current screening procedures. These are decentralized, relatively simple, and inexpensive. They should be retained and the effectiveness should be evaluated on a regular basis and strengthened as necessary. The present system should function only as a screen, yielding a determination of qualification for admission to a centralized selection facility.

Located at the selection center would be the centralized T-41 program where complex assessment would be made of the examinees' psychomotor ability and ability to learn within the flying environment. This learning ability would also be assessed by the use of a low fidelity simulator.

Further medical evaluations would be made; and finally, an attitude test and an orientation period would deal with the problem of self-initiated elimination.

The orientation would focus on the dissemination of realistic information, environmental exposure in an altitude chamber, and intrinsically interesting instruction for pilots.

Successful candidates would enter UPT soon after selection. The entire system would have a research emphasis, including formalized arrangements for assessing students' progress through UPT and throughout their careers. Research and assessment will permit objective evaluation of the future screening/selection system and allow for introduction of new and improved measures from time to time.

Airspace and Air Traffic Control

United States airspace utilization policy is based in part on the common use of airspace and air traffic control facilities by both military and civil aircraft. The growth in civil air traffic in recent years and the continued growth expected for the future represent an environmental effect which must be assessed for its impact upon, and implications for, Future Undergraduate Pilot Training.

Based on current trends, the air traffic control and airspace utilization considerations that can be expected to affect Future UPT significantly in the 1975-1990 time period are:

1) Airspace congestion

2) Air Training Command operating policy to increase use of positive control

3) Lowering of the high-altitude Positive Control Area (PCA) airspace.

Airspace congestion of the substantial proportions is already evident in the United States (although somewhat localized for the present in the northeast and at certain air traffic hubs elsewhere in the United States). DETAILED evidence for predicting that such congestion will intensify and significantly influence Future Undergraduate Pilot Training comes from FAA projections. Tables XII and XIII show the magnitude of these growth projections. Lowering of the Positive Control Area airspace was examined in the context of the ATC policy to increase the use of positive control in UPT operations.

TABLE XII

FAA FORECAST OF CIVIL AVIATION FLEET

Type	Calendar Year 1971	Calendar Year 1981	Increase, percent
General Aviation	134,000	222,000	65.7
Air Carrier	2,580	3,500	35.7
Total	136,580	225,500	65.1

TABLE XIII

FAA FORECAST OF ACTIVITY
(In Millions)

Type	Fiscal Year 1971	Fiscal Year 1981	Increase, percent
Aircraft Operations at Airports with FAA Traffic Control	55.9	170.4	205
Instrument Operations at Airports with FAA Towers	17.3	35.1	103
IFR Aircraft Handled by FAA Air Route Traffic Control Centers (ARTCCs)	24.1	42.5	98.6

Inasmuch as air-to-air operations are not presently a part of UPT, their introduction into any future syllabus will bring new problems to the Air Training Command. One of these will be the controlling of the interface between such UPT operations and the air traffic/airspace environment. Aspects of this problem were included in the analysis of airspace requirements.

The examination of the above problem areas has resulted in a number of important conclusions relative to Future UPT operations and training vehicle equipment installations. These are:

- The Positive Control Area (PCA) airspace floor in the Future Undergraduate Pilot Training environment may eventually be as low as 10,000 feet mean sea level.
- The development of parallel airways, plus associated Standard Instrument Departures and Standard Arrival Routes, will constitute a continuing restriction to UPT operations.
- It is likely that potential UPT air-to-air maneuvers training would not involve all-out encounter practice, and could be accomplished above the PCA floor. In that case it could be controlled in the same manner used for current aerobatic training. Thus, the training may not impose any problems regarding the availability of airspace.

- General aviation will remain a major factor in respect to the collision threat.

- With the exception of low-altitude navigation training, the attainment of complete positive control is feasible for Undergraduate Pilot Training.

- A Collision Avoidance System (CAS) is desirable in UPT operations, although not easily justified on a hardware cost-effectiveness basis.

- The area/navigation display system used in USAF operational aircraft should be used to facilitate Air Traffic Control flexibility in designing local routes and practice areas. Special area/navigation display systems should not be required in Future Undergraduate Pilot Training.

- In view of increasing "tightness" in airspace availability, trainer aircraft equipment (and design) should maximize the permissible altitude operating band, thus affording vertical flexibility to a airspace allocation and to air traffic control.

- Inasmuch as trainer aircraft hand-offs to FAA facilities generally occur very soon after takeoff, the large majority of ground equipment requirements and investments associated with airspace utilization fall to the FAA rather than to the Air Force.

- Aircraft noise is currently a problem in the terminals of the major cities. The annoyance to people has, and will increasingly have, the effect of widespread efforts to curb aircraft noise. Abatement efforts will occur soon after major local judgments are levied on the creators of noise. It is likely that in the years beyond 1975 overflying population centers during certain hours will be restricted to essential needs, such as police helicopter surveillance.

The immediate impact upon UPT of effort toward noise abatement will probably come in the form of restrictions in training hours to perhaps the 7 AM-10 PM local time. It may also result in further constraining air corridors to and from approved training areas well away from population centers. Most current UPT bases are in rural areas with low population density, and the maintenance of current training areas should not be a problem. Therefore, the most likely impact of the effort to control aircraft noise on the Future UPT will be: 1) a possible restriction on the hours during which flying training may occur, and 2) a possible restriction on the areas which may be overflown while enroute to and from approved training areas.

The most important aspect of the airspace and Air Traffic Control problem concerns its effect on the various Future UPT system options. Analysis of each of the system options was necessary to determine the amount of airspace required for operation. These airspace requirements were then compared to present day airspace requirements typical of an average UPT base. All airspace limitations projected for the 1975-1990 time frame were also applied.

The result of this analysis provided the following conclusions:

- All Future UPT System Options could be accommodated within the airspace currently available at UPT bases.

- The implementation of flight simulation in Future UPT allows for a more simplified airspace and air traffic control plan and permits reductions in the number of bases required to conduct Future UPT training.

Detailed description of the airspace requirements for each Future UPT system option will be given later in the report.

FUTURE UPT INSTRUCTIONAL CONCEPTS (APPENDIX E)

A successful training program must be based on sound instructional concepts. In this section all of the important instructional concepts for Future UPT application are addressed. Many of these concepts are controversial. However, it must be remembered that the human learning process has been a polemic topic for centuries.

The important thing to point out about all of these concepts is their shift of emphasis from the instructional motif to the center of instruction -- the student. Probably the most significant change envisioned for Future UPT is a commitment to individualized instruction.

This course of action was identified by analysis of learning theory development. It is becoming increasingly obvious from research efforts that while generalizations on learning (behavior adjustment) are possible, the uniqueness of the individual student's learning pattern requires a somewhat fluid learning environment.

All of the concepts described in this section are designed to provide this type of environment. The first three concepts describe the overall training philosophy and the remaining ones are concerned with individual aspects of the training process.

Curriculum Options

Past trends in UPT curriculum development are presented to demonstrate the changing nature of the pilot training curriculum. Air Training Command historical data for the past 30 year period show that the pilot training program has been in a constant state of flux. Program changes traditionally stem from the following:

- A need for increased production
- A training deficiency or flying safety hazard
- A need for new pilot skills, maneuvers, missions
- A need for cost reduction
- Innovations in training resulting from research or operational tests.

Undergraduate Pilot Training production rates and syllabus flight hours for the 1959 to 1971 time period are shown in Figure 7.

According to ATC records. the generalized UPT curriculum evolved during 1959-1962 in a period of low UPT production requirements. The previous program employed a specialized curriculum utilizing T-28s or T-37s in the primary phase, and T-33s for basic flighter, and B-25s for bomber/transport basic training. The aging B-25 fleet and the absence of a replacement trainer aircraft influenced the decision to use T-33s for all basic training and to employ the single-base concept. The first generalized syllabus called for 262 flying hours in T-37 and T-33 aircraft. This program was updated with the introduction of T-38 aircraft during the 1962-1966 period. The pressure for increased pilot production from available resources resulting from the Vietnam build-up prompted ATC to reduce the curriculum from 262 jet hours to 210 jet hours supported by 30 hours of T-41 screening.

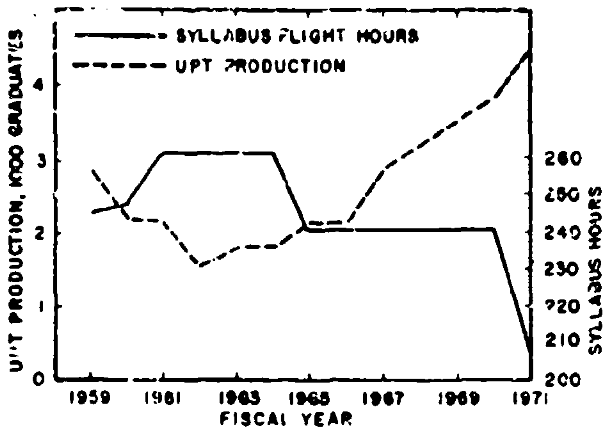


Figure 7. Historical Trends of UPT Syllabus and Production

This 240-hour curriculum was implemented in 1965 and further reduced, for economy reasons (in April 1970), to the current 208-hour UPT curriculum.

This brief account of UPT evolution highlights the reactive nature of the UPT curriculum to external pressures. It is of interest to note the relationship between available resources and production requirements. As shown in Figure 7, when production requirements were low, curriculum hours were expanded; and conversely, as production rates increased, flying hours were reduced.

The Future UPT curriculum will be determined through the Systems Approach to Training. It is the first known application of systems engineering principles to develop a UPT pilot training curriculum. Hopefully, the future UPT system will be developed and validated to the extent that the curriculum will not be subjected to the changes it has experienced in the past.

Pilot Training Concepts

It is a necessary fact of life that continued training is a career-long process for Air Force pilots. Even the most experienced pilots require additional training to transition to a new aircraft or to a new mission. It is for this reason that the Future UPT curriculum must provide the fundamental knowledges and skills that will prepare the graduate for additional training, either through formal advanced courses or operational unit check-out programs. The Future UPT curriculum, in addition to imparting basic pilot skills, should provide as much operational task-oriented training as possible. The degree of task oriented training employed produces the classical dilemma over the pilot training concept to be employed -- generalized or specialized. The major difference between the two being whether the graduate is broadly trained to be assigned to any aircraft category or is specifically trained for a particular category of aircraft.

Generalized Curriculum Features

The current UPT program is the only application of a generalized curriculum for Undergraduate Pilot Training by any major Air Force. The current training program was previously described, therefore, only the significant features of the curriculum are summarized here to illuminate the curriculum and graduate qualifications. The same curriculum is conducted on each UPT base. Students receive all training on a single base which enables them to complete pilot training without an intervening Change of Duty Station (PCS) move. All students receive identical syllabus training and are required to meet the same minimum standards of performance. This, however, does not produce graduates of equal capability. Students are grouped according to their relative standing in the class and then compete for the most desirable assignments based on their ability. It has been necessary to orient the program toward the fighter mission in order to train graduates for the most demanding of Air Force missions. In general, the best qualified students choose fighter/attack type aircraft.

Graduates are considered "universally assignable" to any mission aircraft, although in practice, graduates are assigned (by an assignment council of training personnel) based on their relative class standing and their stated preference. The generalized curriculum

provides qualified pilots for all USAF mission elements, provided that graduates are assigned selectively based on mission demands and individual graduate capability. It is significant to note that this system depends on a distribution of assignments in order to work. It could not, for example, support a requirement of all fighter assignments for one class of UPT graduates. The drop in quality would be immediately apparent to the CCTS units.

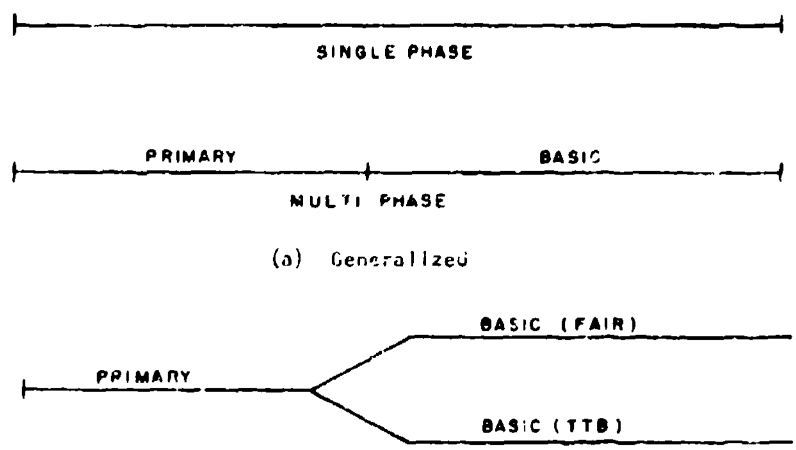
Specialized Curriculum Features

Specialized curriculum patterns are employed by the U.S. Navy and many foreign Air Forces (RAF, French, Italian, Canadian, Japanese, and Russian) for Undergraduate Pilot Training.

Specialized curriculum [illegible] are normally designed to provide common primary training for all students. Students are then divided, according to individual aptitude and motivation, to be trained in separate tracks for fighter and transport/bomber. The multiple base concept, whereby different bases are used for primary and basic training, is often used. However, the single base concept could be employed if the different training aircraft have similar performance characteristics. Specialized training can be tailored more specifically to mission requirements. However, this must be done with aircraft which have been designed to the general configuration and performance of broad Air Force mission areas such as fighter and transport/bomber. Specialized training offers a good potential to develop skills that will enable UPT graduates to more easily transition from UPT to the initial advanced Combat Crew Training School. If subsequent crosstraining to another category of aircraft becomes necessary appropriate formal CCTS training would be required.

Candidate Curriculum Patterns

After a complete analysis of the alternatives, all UPT curriculum options can be reduced to the basic patterns depicted in Figure 8. Two of these represent the generalized approach to training and one represents the specialized. All other approaches were found to be derivations from these basic approaches and had disadvantages that could not be resolved.



(b) Specialized

Figure 8. Future UPT Curriculum Options

Philosophical Training Concepts

Basic learning theory has not changed significantly in the past two decades, and presently accepted principles are in large part based on earlier theoretical statements.

Learning refers to a more or less permanent change in behavior which occurs as a result of practice. It is the process by which an activity originates or is changed through training procedures. Although these and similar definitions of learning are generally agreed upon by authorities, the practical and theoretical ramifications of this concept are so extensive that many men have devoted their lifetimes to the study of learning. Very early work concerned the characteristics of remembering and thinking. This was called associationism and evolved through several approaches to develop a tradition of Associationist Theory. Later work was concerned with observable behaviors (responses) and the causes of the behavior (stimuli). This work is the basic idea of the Stimuli-Response (S-R) Theory. Cognitive Theories are concerned with the perceptual environment and experienced situations in which learning took place. A fourth area of emphasis was on the learner himself and draws on theories of Personality and Motivation as a basis of learning.

It is crucial in the understanding of learning theory to realize that the theorist worked, within independent laboratory situations, studying various aspects of learning and behavior, only later were their individual findings grouped into theories based on the commonality of their interests and conclusions regarding behavior and learning. However, the scope of any individual's investigations may cause the conclusions to overlap with other theoretical categories. All of this serves to point out that there are no universally accepted theories, laws, or principles and the following categorization is only one of many schemes that can and have been used to look conveniently at this vast body of accumulated knowledge concerning learning and to extract from it principles that have practical implications for Future Undergraduate Pilot Training.

The results were grouped under four major types of learning theory: Associationist Theories, Stimuli-Response Theories, Cognitive Theories, and Motivation and Personality Theories. Theories of learning are systematic statements of learning principles that embody philosophical training concepts. In order to facilitate application of learning theory to Future UPT, the major principles and concepts are listed under each learning theory.

Associationist Theories

The early psychologists (or philosophers) did not start with the process of learning but with the characteristics of remembering and thinking.

Associationist psychologists developed the term "memory span," and from experiments developed the concept of the learning curve, a negatively accelerating growth function that accurately describes how the learning process operates through time.

Important principles drawn from Associationist Theories are:

- Ideas can be combined based on similarity, contrast, and contiguity.
- Complex ideas can be formed by putting together simple ideas.
- Simple ideas must be discriminated -- separated from the mass before they may be combined.

Stimuli-Response Theories

These theories about how learning takes place are based on the connection between Stimuli and Responses (S-R pairs) and stem from physiological research.

Behaviorism, also called classical conditioning, was born when the Russian physiologist, Pavlov, reported his famous experiments dealing with the canine salivary reflexes.

The important facts derived from Behaviorist Theories are:

- We are all born with basic S-R pairs called reflexes and we can learn by changing these S-R pairs (conditioning).
- Law of recency -- the student will remember his last response, so stop when he makes the correct response.
- Law of frequency -- repetition and practice strengthen S-R pairs. Frequency of repetition is still important in acquiring skill, and in bringing enough reinforcement to guarantee retention. One does not learn to type or to play the piano or to speak a foreign language, without some repetitive practice.
- The learner should be active rather than a passive listener or viewer. The S-R theory emphasizes the significance of the learner's responses and "learning by doing" is still an acceptable slogan.

Some theorists were proponents of Reinforcement Theory which still depended upon the S-R pairs to explain learning. However, the responses they discuss are not reflexive, they are voluntary responses to the stimulus. The desired response is rewarded (reinforced) to form the S-R pair that constitutes learning.

Basically, this Reinforcement Theory has established the groundwork from which mechanical aids for training, such as programmed instruction, teaching machines, computer aided instruction, and automatic multimedia have developed. The important facts we derive from Reinforcement Theory are:

- The learner is active, not passive.
- The organism must be capable of varying responses
- The total attitude, or set, guides learning and also determines what is satisfying or annoying.
- There are predetermined elements which bring about selective reaction.
- New situations are responded to in terms of similar past situations.
- A rewarding state of affairs reinforces not only the connection but also many neighboring connections that happen to exist.
- The instructor seeks to create a situation in which the correct response is likely and then rewards it.
- Reward serves to fixate the last response because it ends the activity.
- The learner is informed of his success or failure.
- The biggest practical problem is how to get the desired response, initially, so shaping may be used. This means you pick a response close to the desired one and reward it, then build step by step to the desired response.

Drive conditions are important in learning, but all personal-social motives do not conform to the drive-reduction principles. Issues concerning drives exist within S-R Theory; at a practical level it may be taken for granted that motivational conditions are important because they determine the presence of movements which get associated with cues.

Modern instructional technology leans heavily on S-R Theories of learning. These theories have greatly contributed to the understanding of the training process; they have resulted in the development of many educational innovations, such as the use of behavioral objectives, task analysis, programmed instruction, adaptive training, and instrumented techniques for the evaluation of performance, to mention only a few of the highly valuable contributions. However, it would be inadvisable to apply only these approaches to the UPT system concept. Total individualization and automation of training, beyond having dehumanizing effects compounded by the highly stressful task demands could adversely affect such things as washout rate, motivation, and UPT System adaptability.

Cognitive Theories

These theories focus on changes in perception and experience. According to these theories learning is the development of understanding and insight; not eliciting or reinforcing responses.

Within the cognitive theories are several subtheories. The primary outlook is established in Gestalt Psychology. Basically, Cognitive Theory says that learning occurs when the stimulus, response, and reward form a gestalt (meaningful whole) which changes the situation, i.e., insight. The emphasis is on what a person understands, not what he does. This understanding is based on large sections and patterns of life, not the little pieces.

Psycho-social environment and physical environment both play important roles in determining the effectiveness of training. Insight is the formation of a new pattern. Trial and error is a series of small partial insights. Each new discovery is facilitated by experience.

The term "Gestalt" means form or shape, and more broadly, manner or even essence. Gestalt theory differs significantly from Associationism and Behaviorism in that it relates perception to learning and insight. Gestalt Theory assumes that laws of perceptual organization such as similarity, proximity, closure, and continuation also apply to learning. Principles emphasized within Cognitive Theory are:

- The perceptual features according to which the problem is displayed to the learner are important conditions of learning (figure-ground relations, directional signs, "what-leads-to-what," organic interrelatedness). Hence, a learning problem should be so structured and presented that the essential features are open to the inspection of the learner.

- Learning is closely related to perception; therefore, the perceptual environment should be clearly recognizable and understood by the trainee if effective learning is to occur.

- The organization of knowledge should be an essential concern of the teacher or educational planner. Thus, the direction from simple to complex is not from arbitrary, meaningless parts to meaningful whole, but instead, from simplified wholes. The part-whole problem is, therefore, an organizational problem and cannot be dealt with apart from a theory of how complexity is patterned.

- Certain types of learning involve a thinking out process based upon past experience; therefore, as training experiences and materials are presented, they should be cognitively, as well as temporarily, related.

- Select tasks and activities suited to the student's background.
- Stress common features of tasks and present them in common sense units.
- Encourage students to look for relationships and anticipate consequences.
- We learn by achieving understanding and this is more permanently and more transferable than rote learning or learning by formula.
- Goal setting by the learner is important as motivation for learning and his successes and failures are determiners of how he sets future goals.
- The learner should be aware and understand the overall goal as well as the goals of each small step in the learning process.
- Relate tasks to individual goals and needs.
- Teach student to interpret situations and how to get from the present to the goal.
- Cognitive maps are inner routes to your goal.
- Divergent thinking, which leads to inventive solutions of problems or to the creation of novel and valued products, is to be nurtured along with convergent thinking, which leads to logically correct answers.

Motivation and Personality Theories

These theories are Freudian in nature and are clinically based in their formation. They concentrate on the nature of the learner himself and the "self" aspects of training -- self-pacing, self-motivating, self-activizing. They try to bring the simple, experimentally derived laws of learning closer to the complex behavior actively exhibited by human learners. The psychoanalytic aspects of Freud's work have found supporters in the field of learning theory and warrant mention because of their ability to deal with the dynamics of human behavior.

Principles from Motivation and Personality Theory:

- The learner's abilities are important, and provisions have to be made for slower and more rapid learners as well as for those with specialized abilities.
- The learner must be understood in terms of the influences that have shaped his development. We learn by having our behavior changed.
- Learning is culturally relative, and both the wider culture and the subculture to which the learner belongs may affect his learning.
- Anxiety level of the individual learner may determine the beneficial or detrimental effects of certain kind of encouragements to learn. The generalization appears justified that with some kinds of tasks high-anxiety learners perform better if not reminded of how well (or poorly) they are doing, while low-anxiety learners do better if they are interrupted with comments on their progress.
- The same objective situation may tap appropriate motives for one learner and not for another, as for example, in the contrast between those motivated by affiliation and those motivated by achievement.

- Conflicts and frustrations arise inevitably in the process of learning difficult discriminations and in social situations in which irrelevant motives may be aroused. Hence, these have to be recognized and their resolution or accommodation provided.

- The organization of motives and values within the individual is relevant. Some long-range goals affect short-range activities. Thus, college students of equal ability may do better in courses perceived as relevant to their majors than in those perceived as irrelevant.

- The group atmosphere of learning (competition versus cooperation, authoritarianism versus democracy, individual isolation versus group identification) will affect satisfaction in learning as well as the products of learning.

Summary

It is important in comparing learning theories to keep in mind the objective of describing a theory of learning in the first place. The following list describes the requirements for an adequate theorem of learning:

- It must help us understand all processes of human learning.

- It must extend our understanding of the conditions or forces that stimulate, inhibit, or affect learning in any way.

- It must enable us to make reasonably accurate predictions about the outcomes of learning activity.

- It must be a source of hypotheses, clues, and concepts that can be applied to improved training.

- It must be a source of hypotheses or informed hunches about learning that can be tested through classroom experimentation and research, thus extending our understanding of the teaching-learning process.

Using this information, an eclectic approach can be adapted which takes full advantage of all applicable theoretical concepts by choosing the best from each. In this way, learning theory, instructional concepts, training technology, and training equipment can be integrated through the Systems Approach to Training to form the best possible future UPT system. It will be noted that many of the concepts identified in this section are applied to the training systems described for Future Undergraduate Pilot Training.

Systems Approach to Training

The term "Systems Approach to Training" has generated a great mystique which has led many potential users to either avoid the use of the methodology or to claim countless benefits as a result of application of the technique to their particular problem. Nevertheless, the systems approach is one of the most significant training developments of recent decades. It is being employed to design the total future UPT system including the curriculum, instructional concepts, training media (classroom, learning center, cockpit procedures trainer, flight simulator and trainer aircraft), and organizational structure.

The Systems Approach is a process for planning and designing a total teaching-learning environment. A variety of titles are used to refer to the methodology. Among those are

instructional System Development (ISD), Instructional Systems Engineering (ISE), and Systems Approach to Training (SAT). (SAT will be the acronym used for the remainder of the report.) Under the concept of SAT, existing training programs can be revitalized and new programs developed which ensure that students acquire the performance abilities required for future jobs. This does not imply that an entirely new concept of education and training has been developed, but a new management methodology has been applied.

Development

Much of what is known as the Systems Approach to Training (SAT) had its origins in work conducted and funded by the United States Air Force. This work was initiated in the late 1950s and early 1960s and has continued up through the present; however, the airlines were first to demonstrate the application of this technique to pilot training programs.

In the brief history of SAT are found many applications of the approach to design of equipment or layouts of workspaces. Gagne, in his book, "Psychological Principles in System Development," indicated the various uses and applications of what is referred to as the Systems Approach. For the most part, Gagne's book is based upon experiences acquired while working for the Air Force. The first efforts toward identifying SAT were initiated in the mid-1960s by the Training Research Division at Wright-Patterson Air Force Base. In connection with this effort, several documents have been published.

In 1960, the Training Psychology Branch published a document identifying the methods and uses of task analysis information in deriving training requirements and training equipment. This document furnished the initial methodology for applying the systems approach to operational training problems.

Application

The application of the systems approach to the planning and development of an instructional system involves more than the use of current innovations in training media and teaching techniques. Careful consideration must be given to both current and future needs when identifying and planning instructional activities or experiences, and when identifying instructional media, equipment, and facilities.

Therefore, applying the Systems Approach to Training in instructional system development is the orderly process of 1) gathering and analyzing job performance requirements, 2) translating job performance requirements into behaviorally-stated learning objectives and tasks, 3) identifying, developing, and integrating operating resources, instructional techniques, and procedures to provide the required instruction, and 4) assuring achievement of behavioral objectives and confirming that these objectives fully support the job performance requirements. Figure 9 illustrates the SAT model.

While the advantages are many, the Systems Approach to Training should not be considered the panacea for all training ailments. Management personnel must exercise judgment concerning practicality, feasibility, and desirability of implementing systems techniques -- taking into account the nature of problems, available resources, and management needs. Continual monitoring is necessary to protect against reaching a point where the cost of applying systems techniques outweighs the benefits.

There is a danger of over-reliance on systems techniques. Systems techniques will not substitute for management decisions. The techniques should facilitate and enhance these decisions, but not substitute for them.

There is danger of designing training systems around preconceived equipment configurations. Except where system requirements specify some kind of automation, mechanization,

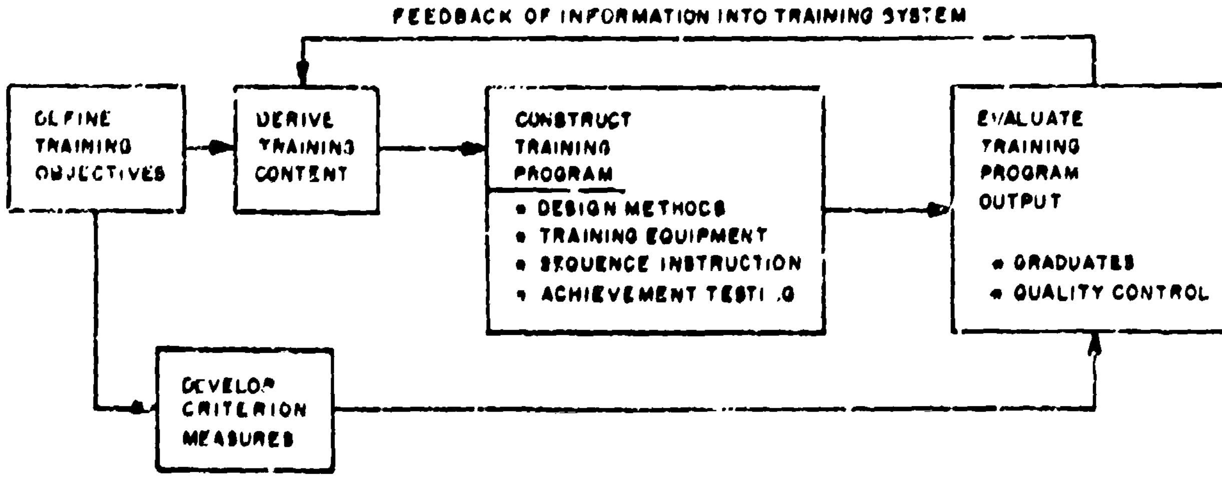


Figure 9. SAT Model

or man-machine interface, equipment should not determine direction of system analysis. By imposing preconceived equipment configurations as system constraints, limits are placed on the number of possible alternatives for reaching objectives.

An excellent example of SAT application is available in current UPT in the academic portion of the program.

The need for improved cost effectiveness in Air Force training programs stimulated ATC to determine the applicability of integrating SAT into the Pilot Training academic program.

Ultimate activity resulted in a 12-man SAT team that became operational in April 1969. The primary goals of the SAT team were as follows:

- Improved standardization and quality control of academic training curricula
- Higher proficiency levels
- Practical and feasible development and use of audio visual devices
- Smooth integration of programmed instructional materials (software) into future training devices (Computer Aided Instruction, Dial Access, Learning Centers, etc.)
- Improvement and validation of present academic curriculum
- Provide a "test bed" for the feasibility of applying the systems approach to flying curricula.

The initial project undertaken by the SAT team was the systemization of the UPT academic program. This included an appraisal and improvement of all applicable training manuals, regulations, audio visuals, and trainer demonstrators that may be affected by application of the systems approach. Seventeen subjects, which comprise 269 hours of academic instruction, were redesignated in accordance with Systems Approach to Training concepts.

The results of this effort have been outstanding and lend considerable weight to the applicability of the SAT concept for the entire UPT program.

Summary

Increased efficiency of training programs can result from use of systems techniques. One way to avoid overextension of an operating budget is to make a careful study of the program before proceeding. This can be accomplished through systems analysis. Components can be identified which might serve equally well for two or more subsystems. Unnecessary duplication and redundancy can be cut.

Improved planning can be achieved through systems techniques which bring into consideration as many relevant aspects as possible and focus attention on defining goals and methods for approaching goals. The application of systems theory calls for bringing together interdisciplinary specialist teams to analyze functions, whose inter-relationships are quite complicated, and to formulate comprehensive plans based on analysis.

Analysis techniques might lead to system design modifications permitting use of the same equipment in both subsystems. Costly errors in structure can be circumvented by being alert to potential trouble spots in the system. Appropriate sensors can be built into the system to detect weak spots.

Training Rate

A properly-paced and -sequenced syllabus of instruction is absolutely essential for efficient pilot training. The rate of training is strongly influenced by the length of each learning session and by the number of different sessions a student can assimilate in a typical training day. This is an extremely complex relationship because of the large number of variables involved. Motivation, motor abilities, induced fatigue, task complexity, and required performance levels are only a few of the factors to be considered in setting a pace for training.

In Pilot Training, several factors, other than the perfunctory performance of the required learning task, must be considered. These factors include skill retention, a reasonable concern that the student will have some available capacity to cope with the unexpected, and the ability to spread his attention over the broader aspects of the task.

The development of coping ability, or capacity for attention sharing, is shown in Figure 10. The learning curve shown with it is typical, showing a rapid acceleration and then slowly peaking out at some performance level. The degree-of awareness curve is shown as decreasing at a fairly constant rate over a period of time.

For example, when the student pilot first begins instruction in turning the aircraft, he very deliberately and conscientiously thinks of moving the stick in the direction of the desired turn, and applying rudder and back pressure until the desired effect is achieved. The act requires his total attention. As his piloting skill develops, the degree of conscious awareness concerning the specific actions required to turn the aircraft decreases. Additional time and practice relegate the process to an almost subconscious level, thereby permitting him to divide his attention and share it with other demands. This process is a function of both time and practice.

The current UPT training rate was established during a period when the aircraft was about the only available training medium. In the more recent past (1965-1971), the ground training system was vastly improved through the application of instructional-systems concepts in the classroom and the planned implementation of multimedia learning centers. Therefore, the means are becoming available which can utilize ground training to better

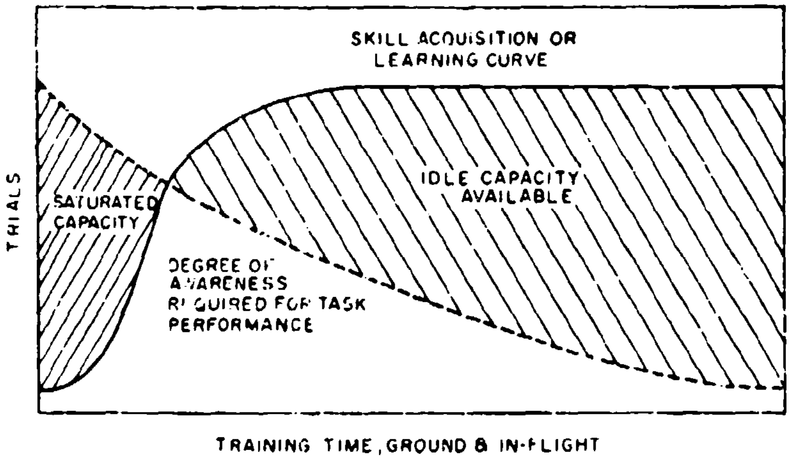


Figure 10. Development of Attention Sharing Ability within a Learning Experience

TABLE XIV

COMPARISON OF CURRENT SYLLABI

Syllabus	Flying Hours	Course Length (weeks)	Daily Progression Rate (cockpit hours)
P-V4A-A, April 70	240	53	1.36
P-V4A-A, April 71	208	48	1.37 (current)
P-V4A-A, (Special)	188	48	1.36

prepare the student to realize the full potential of his aircraft flying time. This improved readiness for training can contribute to higher training quality if sufficient lapsed time-between-aircraft sorties is provided for student preparation. The current training rate is shown in Table XIV and two other UPT courses are shown for comparison. The average daily cockpit-hour progression rate is the number of cockpit hours that are required per training day (aircraft and flight instrument trainers).

The efficient capability for launching training sorties and the historic tendency to measure student proficiency and progress by the number of flying hours has driven the student training rates to current levels.

The training rate of current and past UPT programs was, therefore, derived primarily from operational factors rather than learning considerations. The method for developing the training rate for Future UPT must consider the learning process and the actual time required by the average student to accomplish syllabus-directed training objectives. The methodology adopted to determine the best training rate for Future UPT was as follows:

- Curriculum hours devoted to training sessions in each training media (aircraft, flight simulator, cockpit procedures trainer, classroom, etc.) were determined for maximum learning. This analysis considered fatigue, stress, attention span, safety, task complexity, and operational factors associated with each media.

- In addition to the curricular time devoted to each training session, associated noncurricular time for student preparation, briefing, debriefing, transit, etc. were derived.

- This process will produce the total clock hours (curricular and noncurricular) required for the average student to accomplish all syllabus training. These total hours can then be translated into training days and total course length.

The following curricular hours and their associated noncurricular hours were applied to each alternative UPT syllabus to determine course length.

	Training Period	Noncurricular Hours
a. Aircraft	Approximately 1.3 hours	4.0
b. Simulator	1.0 to 1.5 hours	3.5
c. CPT	1.0	1.0
d. Academic	1.0	1.0
e. Military	1.0	1.0

The total number of training days required for each alternative syllabus is calculated by summing total curricular and noncurricular hours, then dividing by eight which represents the average student duty day. For example:

$$\frac{\text{curricular hours} + \text{noncurricular hours}}{\text{8 hours per day}} = \text{total training days.}$$

The above method applied to the current 208-hour UPT program produces the following results:

$$\frac{\text{725 curricular hours} + \text{1244 noncurricular hours}}{\text{8 hours per day}} = \text{246 training days.}$$

Direct comparisons between today's UPT program and Future UPT can be misleading due to the lack of flight simulation and multimedia learning centers in today's program. However, this formula, applied to the current UPT program, would extend the current program from 48 to 52 weeks.

In summary, Future UPT scheduling should allow for learning factors as well as operational factors in arriving at a training rate. The resulting increase in course length will improve student quality by allowing the student to be better prepared for the training he receives.

Student Evaluation

The assessment of pilot performance in a training environment is a difficult undertaking. Flying involves a large complex of procedural, judgmental, and perceptual-motor activities which complicate performance data recording and interpretations. In a complex system, such as the modern aircraft, the greater the number of interacting elements of the system, the lesser are the chances of deriving easily interpretable and meaningful performance measurements. The persistent problems relate to basic important questions: What to measure? When to measure? What criterion to use? The traditional methods of flight performance evaluation have relied rather exclusively on subjective ratings for individual maneuvers. Essentially, these methods depend on the judgments of experienced pilots observing student performance. This subjective type evaluation is the performance measurement technique used in pilot training programs today.

Although this system is a workable one, it has many shortcomings that are inconsistent with the major training goals identified for Future Undergraduate Pilot Training. Such concepts as individualized training and proficiency advancement cannot be fully implemented without an improved performance measurement system. It was determined after a thorough review of all applicable data that an overall commitment to fully automated performance

measurement should be made. A performance measurement system based primarily on subjective evaluation by a human observer cannot provide the validity and reliability necessary in a systemitized training program.

Having made this commitment, it is necessary to qualify certain aspects of it. First, the human observer will still be part of the evaluation process and will be required to make those judgments that do not lend themselves to automated measurement. Second, the automated system will be an evolutionary development that will be the product of ongoing and projected research. From these general statements, therefore, the development pattern for realizing the goal of automated performance measurement emerges.

Certain near term measures should be taken to improve the present subjective evaluations system; these measures are:

- Expand the present four level grading to a seven level scale to improve the sensitivity of the measurement system.

- Add to the present grading system a requirement for recording the number of trials a student performs to reach the required skill level for the various training maneuvers. This will provide additional sensitivity for the measurement system and will be an aid to structuring a program for proficiency advancement.

- Provide aids to the observer to assist in the recording of performance. Audio recorders should be provided for all training aircraft, and the current research on the Audio-Video Recording System should be continued.

- Provide more detailed performance criteria definition and an abbreviated checklist for observer evaluation use.

All of the above measures will provide an increased level of reliability and sensitivity in the current performance measurement system, and are compatible with the direction of development that measurement methodology is expected to take. However, all of these improvements still will be applied in a measurement system based primarily on subjective human evaluation.

The major shift to objective, automated performance measurement is expected to be achieved with the introduction of the simulator. The research projects presently planned by the Human Resources Laboratory should provide the necessary validation of the criterion performance for each of the training maneuvers. In addition, it will be necessary for flying training personnel to devote considerable effort in support of these research projects in order to identify all training tasks in behavioral terms and to specify the various tolerance levels of performance.

The initial application of objective performance measurement using the simulators will provide the necessary experience for decisions on further research and validation -- always moving toward the goal of automated performance for all phases of flying training.

Student Management

The desire for an effective management system that recognizes individual student ability is universal. The civilian educational community has taken many steps in recent years to establish programs that recognize individual student abilities and allow students to progress at their own pace. Some of these methods are possible only because of technology application in the form of computers and multimedia devices. The military educators/

trainers have pioneered development of many of these devices for improving training. However, the methodology of application in the military is usually one of improving overall training efficiency and not one of individualizing training. With the training devices envisioned for Future UPT, a completely individualized training approach should be considered the ultimate goal. However, because certain problems in this approach have yet to be resolved, immediate application of complete individualized training is not possible.

An alternative approach -- homogeneous ability grouping and variable training rate -- was identified for immediate application. It provides an important first step toward completely individualized training.

The approach used to apply homogeneous grouping and variable training rate will be to plan the average and manage the extremes. Figure 11 shows the curve of normal distribution with the breakdown of percentages that will be used as planning factors. This curve is used as a starting point because behavioral scientists believe that many of the traits studied by educators, such as intellectual ability, are distributed among people in an approximately normal fashion.

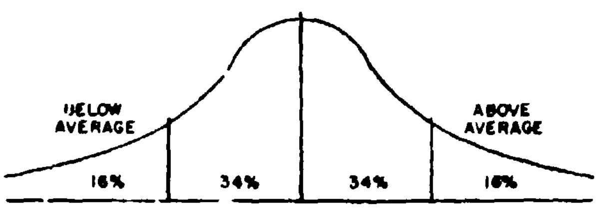


Figure 11. Student Ability Distribution

Students will be grouped according to ability levels derived from the screening and selection process. Initially all groups will be trained at approximately the same rate, and necessary adjustments in the groupings made to account for improper placements.

After this period, the above average group would be increased in rate of activity, and the slower group decreased in rate of activity. The average grouping would maintain the training rate schedule established initially. Identifying and planning for these groupings allow for improved management for the slower students and increase their chances for completing the program. Above average students will benefit from the increase in training continuity achieved by matching the rate of training with their recognized ability.

Naturally, using the normal curve as a planning factor does assume approximately a normal distribution of students. This will be true over an appreciable number of student entries. However, it can be expected that some group distributions will not fit the normal curve, and, therefore, the planning must account for these perturbations.

The system can tolerate appreciable variations in the number of students in the three groups. However, large variations are not anticipated because the improved student selection process should be able to provide each UPT base with an equitable distribution of ability levels in students.

The combination of homogeneous grouping and variable training rate provides the best alternative for achieving the concept of individualized student training in Future Undergraduate Pilot Training. The advantages of increased motivation for above average students and increased help for below average students are meaningful and can result in economies by reductions in attrition.

Instructor Personnel

Instructor personnel deserve special consideration for two primary reasons: 1) instructors have a direct impact on training quality, and 2) they can influence the career intentions of their officer students.

Existing concepts regarding the role of the instructor evolved at a time when training technology at the instructor's disposal consisted of little more than a blackboard, chalk, and an eraser. In subsequent decades great strides were made in the application of learning theory, educational methods, and instructional technology. While many changes have taken place in education, comparatively few have taken place with regard to the function of the flight instructor. The changes which have occurred are mostly in the instructor's style and not in his role or basic approach to training. He is still conceived of as a conveyor of information rather than a person whose responsibility it is to ensure that instruction takes place through available training media.

Instructors in today's UPT program are Air Force pilots who are trained in instructional techniques to use the training aircraft as the primary instrument of instruction.

The Future UPT training environment will be significantly different than that of today. A much greater percentage of the total pilot training process will be conducted on the ground in the classroom, learning centers, cockpit procedures trainer, and flight simulator. In this environment, the flight instructor is expected to assume greater responsibility for the student's total training, rather than specialize as he does today in only flight instruction.

The Future UPT instructor will not be considered as an isolated entity. Rather, his function will be viewed in terms of the comprehensive training system.

The Future UPT flight instructor will have available the total resources of the training facilities in order to help his students achieve the training requirements. Typically, the IP training manager would provide a succession of training experiences for his students which will culminate in the validation of the students' skills and knowledge in the flight environment. The flight instructor as a training manager would be required to possess more advanced instructional technology knowledge than is now typically found in the IP corps and, thus, would necessitate increased instructor training. Introducing the training manager concept could significantly increase the continuity in the learning experience for the students. The manager will know where his students stand with respect to the mastery of the skills and knowledge required to satisfy all of the training requirements. With the assistance of computer managed instruction, he will be in a better position than ever before to provide the exact, meaningful learning experiences which will lead the student to new knowledge or correct existing deficiencies.

This increase in the role of the instructor required an examination of the ratio of instructors to students required for conducting UPT training.

The authorized student/instructor ratio of today's UPT program is approximately 2:1. However, this is an authorization which has not been fully manned in recent years. The real-world situation in current UPT is a ratio of about three students per Instructor Pilot.

Experience to date indicates a need for additional IP resources due to the more thorough ground training program with its demands on the Instructor Pilot's time. It is anticipated that Future UPT will require a real-world student/IP ratio of 2:1 to be fully effective. The increased responsibility associated with the training manager concept, instructing flight-simulator lessons, and flying all dual sorties provide justification for more adequate IP manning in future years.

Finally, it was determined that the Future UPT instructor corps should continue to be made entirely of rated Air Force officers. It would also be desirable that they be volunteers for instructor duty and receive the benefits of a stabilized tour of approximately three years. It is also desirable that personnel programs be established to enrich the Future UPT instructor corps with an experience mix proportional to the force structure. A program designed to rotate selected pilots from all the major commands through a tour as flight instructors will provide meaningful impact on student assignment goals and career intentions.

Dynamic Observer

Dynamic observation is the Active involvement of a secondary trainee in a given training situation. Although dynamic observation is usually thought of in terms of an airborne environment, it can be applied to any training situation -- on the ground or in the air. This distinction is very important when the Dynamic Observer concept is considered for application in Future UPT because many of the advantages claimed for it could be achieved in a ground training environment.

Although little, if any, statistical evidence can be found to support a positive position in favor of dynamic observer, subjective and anecdotal data do suggest that the dynamic observer concept offers training potential. It must again be remembered that with the exception of airline transition training, all dynamic observer evaluations have been carried out in the absence of sophisticated ground-training hardware and software.

Based on the assumption that the dynamic observer concept is potentially useful in Future Undergraduate Pilot Training, possible areas of application were considered. Since it has been shown that dynamic observer principles can be applied to many learning situations, the application of dynamic observer to both airborne and ground training activities would appear feasible in Future Undergraduate Pilot Training, especially in light of the future training environment. Therefore, three specific applications of dynamic observer were examined: 1) the first application of dynamic observer was that mode most commonly discussed -- the aircraft with a third seat designed for dynamic observation; 2) a second application was that dynamic observer situation which is sometimes referred to as the "team-flight," (students flying with students); and 3) the third application of dynamic observer was in the ground training situation.

It was determined that at the present time dynamic observer advantages could not be quantified to the degree necessary to justify the added expense of a three-place training aircraft over a two-place one. However, where dynamic observer could be employed at no penalty in aircraft design and operation, it should be used (in the specialized Tanker, Transport, Bomber phase).

The application of team-flight dynamic observation appears quite desirable, and provides many training advantages. Relative to former USAF use of the team flight approach, where students of the same skill level rode together, a worthy innovation will pair a novice with an advanced student for selected rides.

Although this approach is well known within the Air Force, it attains new stature when considered within the rationale of dynamic observation. The radar control environment of Undergraduate Pilot Training airspace provides a tool for reducing much of the flying safety hazard often associated with the team flight concept. This positive control of training aircraft will be further refined in Future Undergraduate Pilot Training.

Finally, the application of flight simulation in Future UPT offers the possibility of achieving many dynamic observer advantages. Simulator cockpits designed with two seats can utilize a dynamic observer on solo type lessons while the IP is at the instructor console rather than in the cockpit with the student. This would be much the same as team flights in the aircraft.

The optimum advantage of dynamic observer concept appears to be its use during the early phase of any new learning situation. Speaking in terms of "newness," the totally naive student probably has the most to learn. As his training proceeds, dynamic observation will realize less effectiveness, except when encountering new tasks. Again, careful trade-off between ground and air practice must be made relative to actual training value.

FUTURE UPT TRAINING MEDIA (APPENDIX F)

The selection of training media for Future UPT is an extremely important process. However, it does not have the emphasis in the Mission Analysis approach that it has had in previous flying training program designs.

In the past, the training aircraft has been designed to come as close as possible to the flight performance of the front line aircraft and then after the design was completed, the training program was developed. The mission analysis approach differs from this traditional approach. The primary difference stems from an emphasis on what needs to be trained -- i.e., training requirements. A second difference and an important one is that the array of devices available for accomplishing the training in the future is much broader than in the past.

Each of the training media selected for Future UPT will be described. Figure 12 shows their inter-relationship. The significant feature of Figure 12 is that the media are ranked according to capability and economy of operation. The principle of design in the training media application is to accomplish the training in the lowest cost device.

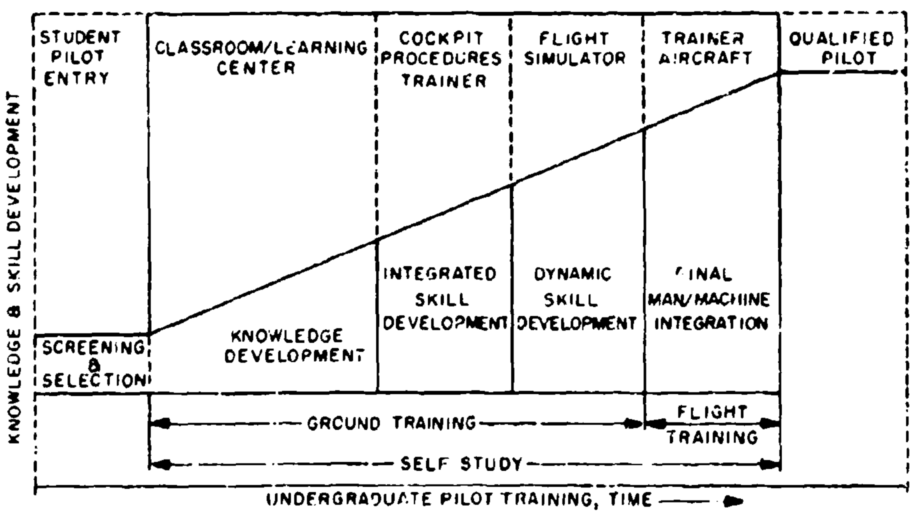


Figure 12. Training Media Progression

Classroom and Learning Center

The classroom and learning center provide the primary training environment for acquiring the knowledge prerequisites in the pilot training process. The future training requirements previously identified create an academic course requirement much the same as today in content. However, several new training requirements have necessary subject matter that constitute an increase in academic training. For example, decision making, energy maneuverability, air-to-ground fundamentals, radar, and air drop fundamentals are all new course requirements.

In addition, flight maneuver instruction will be included in the Future UPT academic area. There will be more emphasis on the student learning flight techniques in a learning center environment as opposed to the current method of the instructor briefing the student.

Current UPT employs standard academic buildings with ten classrooms. The buildings are well designed and feature rear screen projection, variable control lighting, and sound proofing. Classrooms, as depicted in Figure 13 are designed for 30 students but are capable of accommodating up to 40 students on an overload basis. This standard building exists o. is programmed for all UPT bases in the near future.

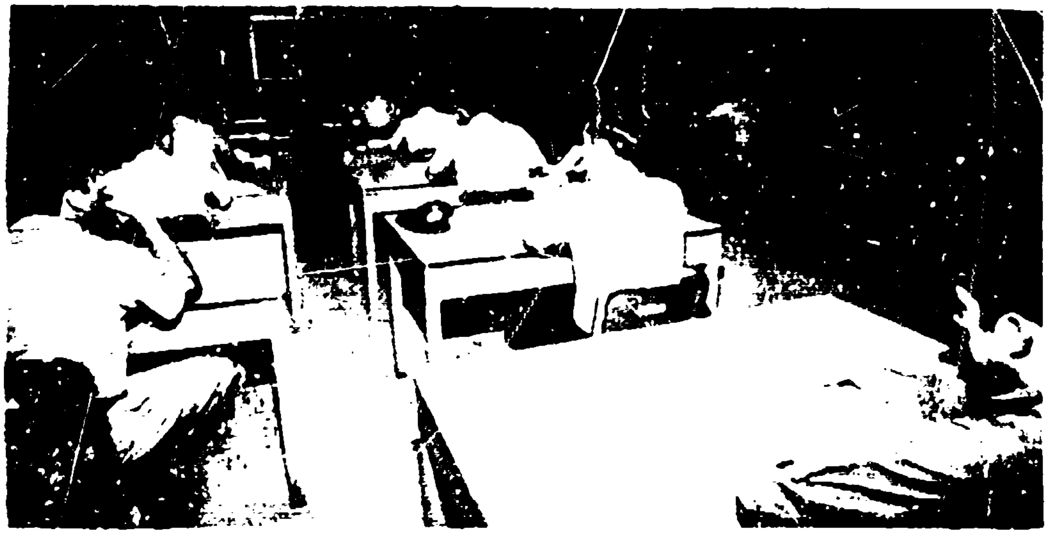


Figure 13. A Standard UPT Classroom

It appears that academic training, as currently conducted in the classroom, can also be individualized through the multimedia learning center and computer based instruction. This will be a developmental process which is expected to extend over a period of years. The logical approach to implementing individual training would appear to be a gradual transition from group-paced classroom training towards individually-paced learning center instruction as training technology makes such a transition cost effective. The ultimate goal of individual progression can be justified only on a basis of cost effectiveness.

Two multimedia learning centers are operating within UPT at this writing: 1) Williams AFB, Arizona; and 2) Moody AFB, Georgia. Based on the general success of media instruction in flying training and academics, learning centers are planned by ATC for all nine UPT bases. In general, these centers will be relatively unsophisticated, and will contain (during the 1972-1974 period) sound-slide and super-8 mm. film self-study devices. With these developments currently in progress, the future of the classroom is dependent to a great extent upon the future trends realized in multimedia and computer based instruction. As Future UPT realizes a real movement towards individualized instruction through the application of advanced instructional technology, then the classroom as known today will slowly cease to exist.

In the transitional period, from 1975 to 1990, the classroom will be in a state of evolution. Learning centers presently are confined to enhancing flight-line training. As centers and media become well established in UPT, it will be natural to teach classic classroom subjects by using media which are found in the learning center. The guiding concept

of a systems approach to training will tend to accelerate the use of this modular, mediazation of academic materials to get a more effectively prepared student for any specific airborne sortie. This "readiness" approach to training will result in a further reduction in the artificial separation between academics and flight line. As a final goal, it is envisioned that formal academic material will be broken down into one or two hour modules of instruction for individual self instruction. All core curricular materials required for students would be available in the learning center. In addition a wide variety of remedial teaching packages will be available to be scheduled for individual students on an as needed basis. Figure 14 shows a typical learning center arrangement. The final consideration for the future academic requirements concerns the application of computers in the instructional process.

Figure 14. Typical Learning Center Arrangement

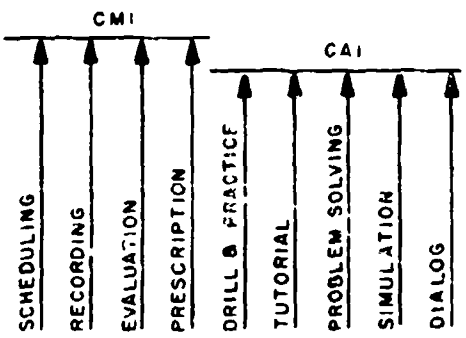


Figure 15. Computer Based Instruction Capabilities

Two major aspects in computer based instruction are computer manage instruction (CMI) and computer aided instruction (CAI). These two capabilities represent two ends of the computer based instruction continuum. Figure 15 illustrates the different levels of capability. CMI represents a limited capability well within the state of the art and is currently employed in UPT for record keeping and scheduling. Essentially, CMI can monitor and evaluate student responses (with programmed limits), and apply statistical treatments (prescription) to data and printout results.

This printout may be in any number of forms including graphs depicting student progress. In a CMI system, the student is guided directly by the computer, or through an instructor, to media and materials which are appropriate to his level and rate of progression. Computer managed instruction can be used to implement functions such as: 1) the development of a scheduling system for optimally matching students with learning resources, and 2) the development of an appropriate student instructional-record system.

Computer Aided Instruction capability begins where CMI capabilities end. The simplest CAI level starts with drill and practice. At this level, a fixed linear sequence of problems (no branching) is presented. Knowledge of Results (KOR) is presented as the student responds, while student errors may be corrected in a variety of ways. No real-time decisions are made, however, for modifying the presentation of instructional material as a function of the student's response history. From drill and practice, CAI will progress through the tutorial and problem solving phases and, finally, reach the dialog form of CAI which represents the ultimate goal in computer assisted instruction. It is a truly interactive form of programming which allows the student to converse with the computer using free-form input. This role of the computer is seen as an evolutionary one. By allowing CAI to develop along with the learning center, a broad transition period can be realized which allows opportunity for the planned and systematic use of the more sophisticated application of CAI in Future Undergraduate Pilot Training.

The major obstacles to success in this approach will undoubtedly be in the software and management aspects of the problem. There is little question concerning the availability of hardware items, in fact, most hardware items are already available as off-the-shelf items or are in advanced stages of development.

Determining techniques of use is primarily a research problem and must be resolved by the training research community. Application, when once defined as cost-effective, is a management challenge which ultimately determines the real look of Future Undergraduate Pilot Training Learning Centers and Classrooms.

Procedures Trainers

Procedure training on the ground has always been a part of aviation training. Initially, this type training was accomplished in the aircraft while it was not in use. As aircraft became more complex and their utilization increased, this use of the aircraft became less acceptable and finally impractical. As a result, ground devices were designed for use in place of the aircraft. While these devices -- frequently called procedure trainers -- were acknowledged as necessary in the training process, their quantitative training value has never been determined.

Future Undergraduate Pilot Training should employ a family of procedure trainers, each designed to accomplish the required level of training. Their training value has been estimated based on procedure trainer application in current UPT in the Air Force and the other services as well as the airline training program.

The procedures trainers should be applied in Future UPT as shown in Figures 16 and 17. However, all procedural activity that must be time shared with flight activity will be further trained in the higher order training devices (simulators and aircraft). In addition, the procedures trainers will be used to provide continuation training in manipulative patterns and thought/motor sequences for those procedures not routinely encountered in normal flight missions.

The procedure trainers identified for Future UPT are the cockpit mockup trainer, the cockpit procedures trainer (noncomputing), and the cockpit procedures trainer (computing). The cockpit mockup is a very simple device designed to provide introductory training in cockpit layout and pre-engine start procedures. The cockpit procedures trainer (noncomputing) provides a cockpit structure, ejection seats, dummy flight controls and dummy controls/switches for accomplishing all normal and emergency procedures. This device is referred to as CPT-1. CPT-1 will provide initial training in all normal procedural tasks from engine starting through engine shutdown. It would also provide initial training in emergency procedures.

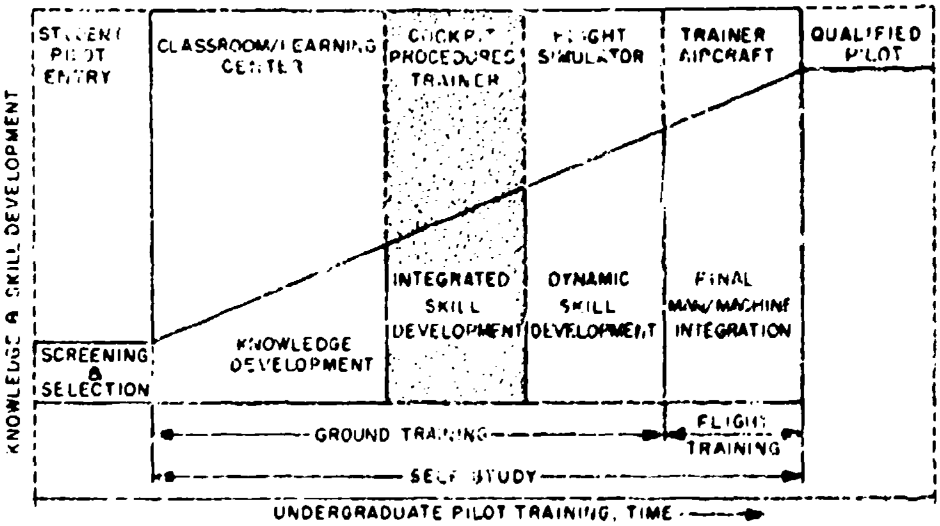


Figure 16. Training Media Progression

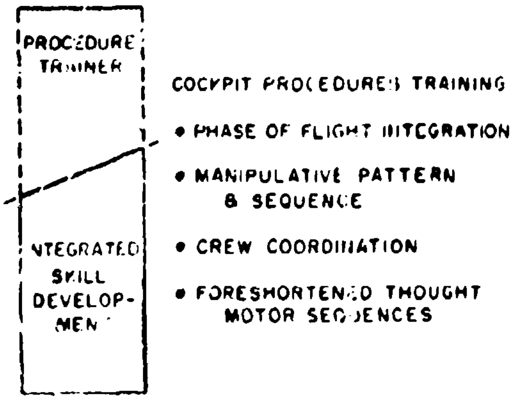


Figure 17. Cockpit Prodedures Training Segmant

The cockpit procedures trainer (computing) provides all the features of the CPT-1 combined with operating instruments and a small computer capability to provide the instruments with aircraft system logic. The role of CPT-2 in the training scheme is to provide continued readiness training of emergency procedures. The CPT-1 provided the initial training in both normal and emergency procedures. However, unlike normal procedures, the developmental reinforcement of emergency procedure skills in other training devices cannot be assumed. Due to the contingency nature of this body of procedures, a clear well-developed plan for review and practice of these procedures is necessary.

A summary of the training for each of the procedure trainers is shown in Figure 18. Their training sequence is designed to follow the systems approach to training.

Each trainer is employed to its maximum training capability and fidelity design is specified to meet the training requirement. Therefore, the family of trainers complement each other and achieve overall system efficiency. It should be pointed out that although the CPT-1 could do the job of the mockup trainer and CPT-2 could do the job of CPT-1, it would be inefficient to apply these trainers in that fashion. In both cases, the trainers would possess unnecessary fidelity for the lower level training; and unnecessary fidelity is equivalent to unnecessary cost.

Finally, the flight instrument trainers currently used in UPT were considered for use as procedures trainers in Future Undergraduate Pilot Training. The operating and support costs for these trainers (T-4/T-26) are considerably higher than those projected for the new trainers. In addition, many of the T-4/T-26 trainers are past their design life.

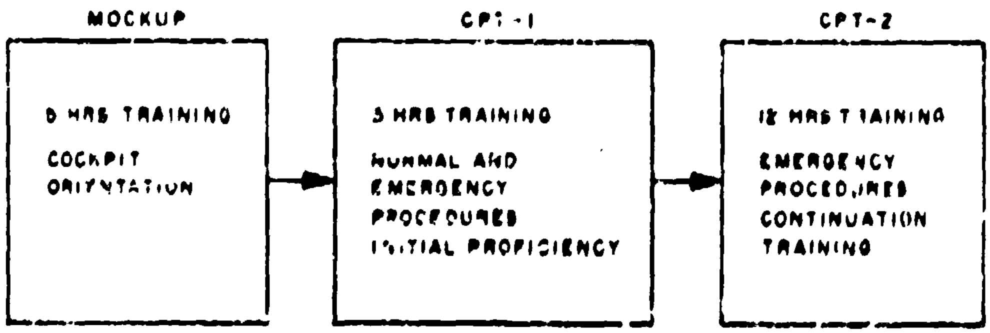


Figure 18. Procedures Trainers Summary

The projected implementation date for the new family of procedures trainers is approximately the 1976 time frame, concurrent with TS-2 simulators. By this time, the majority of T-4s/T-26s will have reached their design service life, and it will not be economical to maintain them in operation.

These facts supported the conclusion that the ground trainers currently used in UPT have no place in the future UPT picture.

Flight Simulation

One of the most important areas concerned the application of simulators in Undergraduate Pilot Training. Many precedents on simulator application in different types of pilot training programs had been established prior to the Mission Analysis. However, there was no precedent for simulator application in any undergraduate pilot training program.

The Mission Analysis was charged with the requirement to be definitive about future UPT simulation. Basically, it was necessary to determine the role of simulation in the overall training scheme and then to specify the simulator design or designs that would accomplish the assigned training tasks. Actually, this apparent two-step process is extremely interrelated.

The process used for deriving flight simulator requirements is shown in Figure 19. The critical steps in this derivation are Blocks 4 and 5. It is in these areas that much simulation controversy centers.

Major Arguments

There are two major arguments that have surfaced throughout this study and deserved to be addressed at the outset in order to make the findings clear.

The first major argument centers around what simulator technology has to offer. This line of argument is usually established by those identified with simulator research. They contend, with some meaningful justification, that simulation technology is progressing rapidly and that full mission simulation for UPT is but a short time away. In order to evaluate the merit of this contention, the Mission Analysis made a rather extensive review of all literature on flight simulation, consulted with many of the recognized authorities on flight simulation, and flew a great variety of flight simulators, both training and advanced research devices. In addition, all of the major simulation research efforts underway or planned were reviewed to determine the level of technology applied and anticipated results.

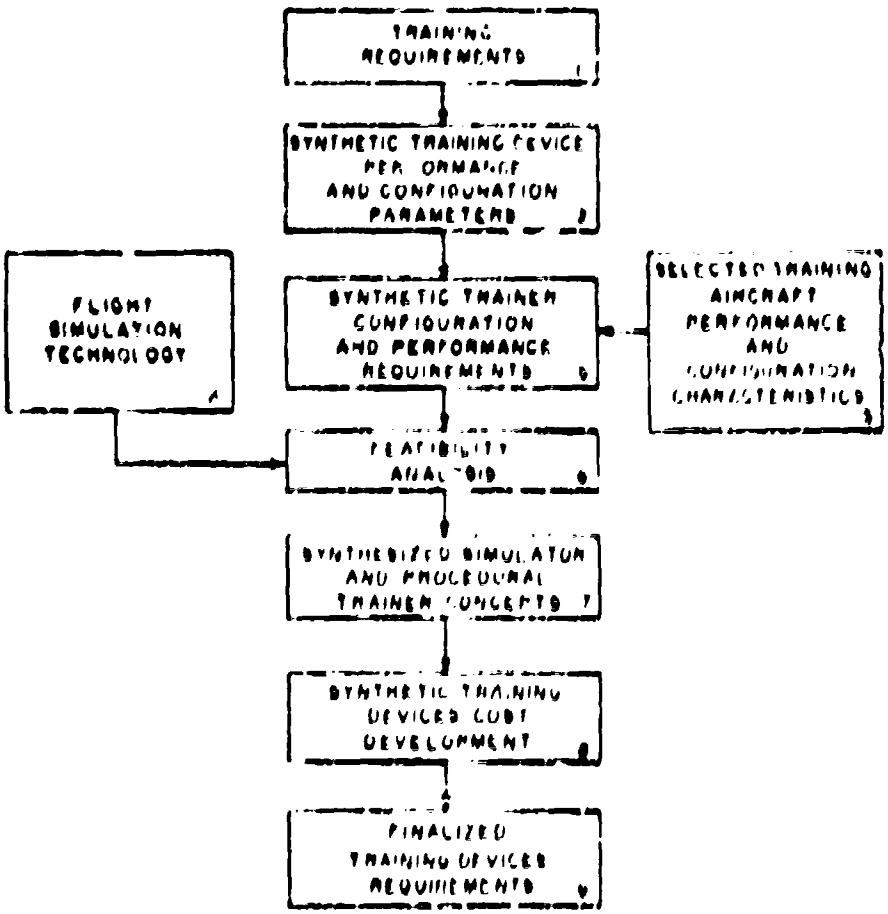


Figure 19. Process for Deriving Flight Simulator Requirements

The conclusion drawn from this effort is that full mission simulation in UPT should not be employed until the 1980 time period. The major factor that determined this conclusion was the lack of evidence that full mission simulation can be correctly applied in the UPT training environment. In addition, there is also a lack of evidence on the type of simulator that will be needed to achieve full mission training. The on-going and projected research efforts by the Air Force and Industry should provide the necessary evidence for more educated decisions on full mission simulation around 1977-1980.

It should be noted that technological projection was not a decisive factor. There is no question that technology can produce a full mission simulator before 1980. However, if it is produced prior to 1980, its design features and training value would be based largely on conjecture.

The second major argument centers around a conflict of interest. It is usually established by those who could be identified as the operators. They recognize the potential that simulation has to offer -- especially if they have actually flown a modern training simulator. However, they view the simulator in a competitive role with the aircraft; realizing that the only way high fidelity simulation can be justified in pilot training is by a reduction in the level of real flying. As a result, many of the indictments raised against simulation center around what it cannot do compared to the aircraft. The positive approach is often ignored. In order to evaluate the merits of these

arguments, the Mission Analysis examined in detail the training requirements, the training maneuvers, and the training environment. The findings revealed that substantial reductions in actual flying time can be made by using simulation and that the pilot quality can be increased as a result.

Simulator Designs

Applying these two conclusions to Future UPT resulted in a two-phase implementation plan for simulation. A TS-1 low fidelity simulator was considered in support of a light-propeller primary aircraft. This option was dropped from consideration, as will be explained later in the report. The first phase centers about the TS-2 (see Figure 20) simulator designed for accomplishing the majority of instrument training. The TS-2 is a high fidelity simulator which incorporates the following design features:

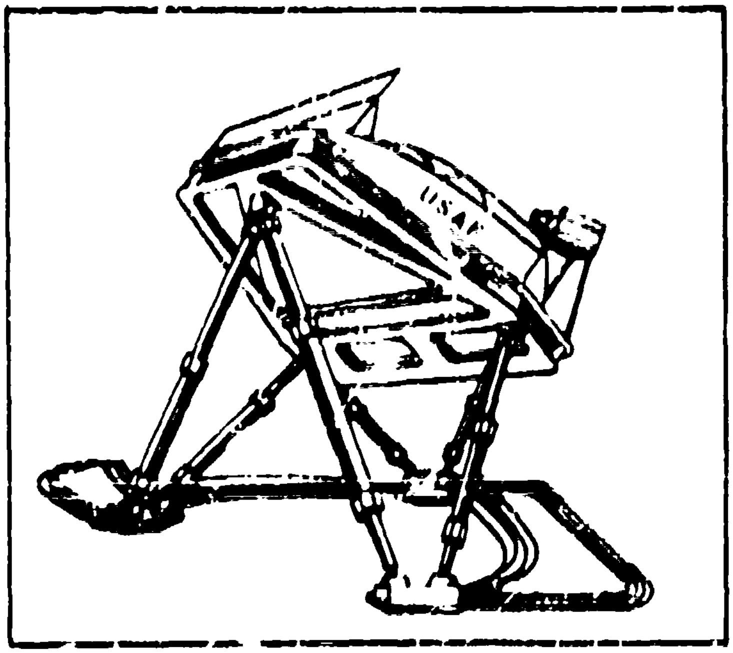


Figure 20. Artist's [illegible] of TS-2 Flight Simulator

Fidelity of Simulation ——

The fidelity of simulation will be that which is currently available in off-the-shelf digital flight simulators such as the F-4 and 747. Particular attention will be given to ensure that the control feel and response characteristics accurately represent those of the training aircraft in the flight envelope range normally encountered in instrument maneuvers.

Computation ——

Digital computation was selected because it is more flexible than analog or even hybrid computation. Digital computation also provides for economy in terms of maintenance requirements. The computer math model provides rigorous simulation of aerodynamics, engines, and systems. In addition, the digital computation provides the capability to incorporate, through computer software, many advanced instructional features.

Auditory Simulation ——

Current off-the shelf auditory simulation was selected.

Advanced Instructional Features ——

The following proven advanced instructional features were selected for Future Undergraduate Pilot Training:

- Automatic control of initial conditions
- Automatic demonstration
- Automatic malfunction insertion
- Automatic monitoring of procedures items

- Automatic permanent recording of results
- Student feedback
- Automatic performance comparison.

Motion System —

A six-degree-of-freedom motion system is required to provide the full range of postural cues (vestibular and proprioceptive). The motion platform will be designed to accept either T-37 or T-38 cockpits for near term application and to accept the cockpits of new training aircraft when they are implemented in the Future UPT program. This design concept and the capability of the digital computer to be reprogrammed with flight equations of different aircraft will enable the simulation motion, visual, and computer systems to be used for new as well as current aircraft. The six-post-motion-system was selected for the following reasons:

- Six post motion systems are off-the-shelf technology with previous training applications.
- Facilities requirements are held to the minimum by use of off-the-shelf six-post motion systems (rather than a cantilever motion system).
- Three companies (Link, Reflectone, Franklin Institute of Technology) are known to have experience in producing six-post motion systems.

Visual System —

The visual system will be a model/probe television system. The television projection system, fed by a three-dimensional terrain board, will provide adequate visual cues for transition from IFR approach to VFR landing, plus an excellent probability of providing cues suitable for low-level flight, straight-in landing, takeoff, and area work. A scale factor of approximately 1400:1 and physical dimensions of 30 feet x 60 feet for the terrain board, yields approximately seven nautical miles by 14-nautical miles coverage. This visual system was selected for the following reasons:

- Proven training value in takeoff and approaches based upon airline training experience
- Capability of training from instruments to visual transition for straight-in landing
- The capability to use the image generation portion of the visual system in conjunction with more than one simulator (though not simultaneously).

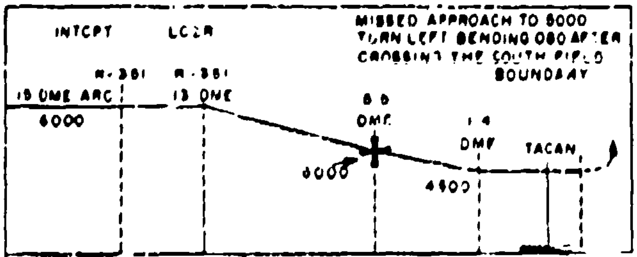
The total system is of negligible technical risk. The TS-2 simulator will be procured in complexes of four cockpits each. Each simulator cockpit will have image display equipment, but two cockpits will time share one terrain board. Thus, at any time one-half of the cockpits will be on visual operation, while the other half of the cockpits will be on instruments.

The external instructor's station will accommodate two instructors, each will monitor two simulators. An external Cathode Ray Tube will provide the instructor a repeat of the student's visual scene.

The TS-2 flight simulator will be utilized for training in flight characteristics, emergency training, full instrument training, VFR approach/landing and takeoff. The visual system will permit training in a very critical area -- transition from IFR to VFR flight and takeoff and landing.

The transition from instrument flight conditions to visual flight conditions during an instrument approach to landing is an important capability to consider in the selection of the visual system for the TS-2 flight simulator. In today's program, training for this critical task is unrealistic in the trainer aircraft due to hooded flight in the back seat of the T-38 and the high minimum altitude of practice approaches at UPT bases. Figure 21 shows average minimum altitudes for TACAN, VOR, ILS, and GCA approaches at UPT bases, and the typical actual minimum altitudes for these approaches. This situation is due to restrictions imposed by other phases of training being conducted at UPT bases. This causes instrument training in the trainer aircraft to be unrealistic in today's environment. In addition, the student understands before an approach is initiated that it will terminate in a missed approach. As such, the student can easily become missed-approach oriented. In effect, the student establishes an incorrect "habit pattern" by seldom performing an approach in the manner that it would occur in normal operations. The TS-2 flight simulation will have the capability to overcome the inefficiencies of the aircraft for instrument training by providing the total instrument environment including approach, air traffic control, and runway environment, as well as variable weather ceiling and visibility conditions.

Furthermore, accomplishing instrument training in the TS-2 simulator reduces congestion and operational complexity at the UPT bases and allows for increased training efficiency in the flying done in the contact, navigation, and formation phases. More details on the application of TS-2 will be presented later in the report.



AVERAGE DECISION HEIGHTS (DH) AND MINIMUM DESCENT ALTITUDES (MDA) FOR PRACTICE APPROACHES AT UPT BASES

	TACAN	VOR	ILS	GCA
PRACTICE	4600' AGL	5080' AGL	300' AGL	660' AGL
ACTUAL	600' AGL	800' AGL	200' AGL	150 AGL

Figure 21. Minimum Altitudes for Practice Approaches

The design of the post-1980 candidate full mission flight simulator was based upon examination of the projected simulator technology, on-going research projects and the training requirements for Future Undergraduate Pilot Training.

The design and implementation of the TS-3 was based upon the following assumptions:

- A wide-angle visual display system capable of providing training in the maximum number of Future UPT training requirements will be available.
- Computer Image Generation will prove successful in providing the visual image generation necessary for full mission training.
- Continuing motion system research and development will be able to define motion system requirements to support full mission training.

The final configuration of TS-3 will depend to some extent on the results of the following simulation research projects: Advanced Simulator Undergraduate Pilot Training, F-4 area-

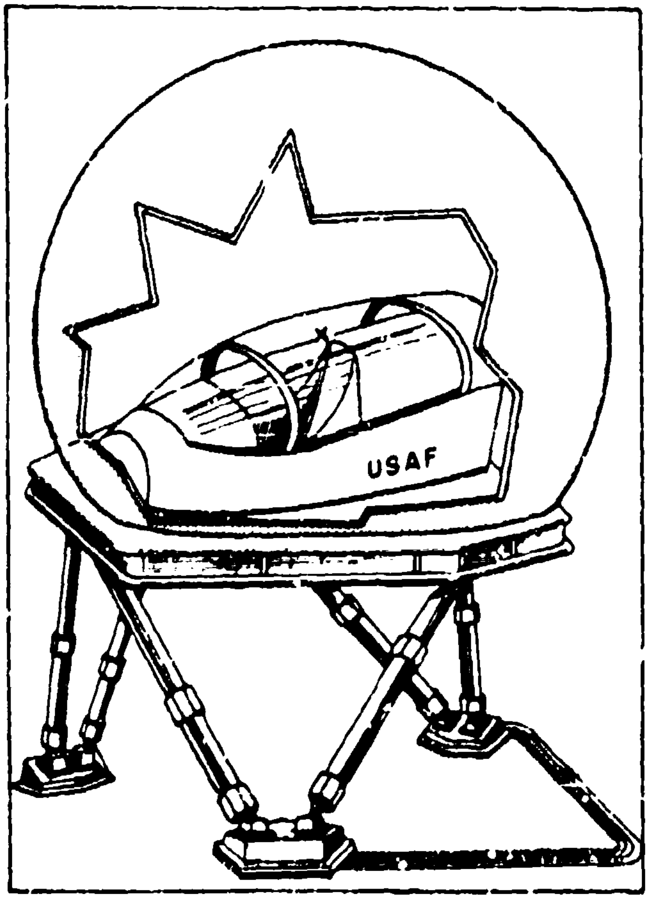


Figure 22. Artist's Concept of TS-3

of-interest program, air-to-air combat simulator, the Army Synthetic Flight training simulator program, and developments in industry. In addition, a TS-X flight simulator with a dome type visual display system is required to evaluate and validate the dome wide-angle display technique. The TS-3 simulator is expected to be similar to TS-2 except for the visual systems. Figure 22 is an artist's conception of TS-3. The design features are projected as follows:

- (Fidelity of Simulation)
  Continued improvements in the area of fidelity of simulation can be expected. The fidelity level of simulation should always be that which is available off the shelf during the post-1980 time period. Research efforts such as ASUPT will be investigating the relationship of fidelity to training and should be closely monitored.

- (Computation)
  Digital computation should be used for the TS-3 flight simulator. The speed and capacity of digital computers is expected to improve over the present state of the art and, thus, should continue to be ideally suited to the needs of Future Undergraduate Pilot Training.

- (Auditory Simulation)
  1980 off-the-shelf auditory simulation should be included in the TS-3 flight simulator.

- (Advanced Instructional Features)
  The instructional features planned for TS-2 should also be incorporated in TS-3. In addition, research on adaptive training should be completed by 1977 and a decision can be made with regard to its application on the TS-3 flight simulator.

- (Motion)
  The six-degree of motion system planned for TS-2 should be adequate for TS-3; however, research in motion systems such as those envisioned for ASUPT should be monitored. Research on large-amplitude motion systems should also be conducted. The design problems of g-seats (being investigated in ASUPT) should be resolved by 1977.

(Visual Systems)
Developments in Computer Image Generation (CIG) should be closely followed to determine its suitability for application in the TS-3. This technique of image generation offers the flexibility to simulate the full UPT mission. The dome and mosaicked CRT displays offer methods of providing increased fields of view and improved display perspective. The CRT technique is being explored in Advanced Simulation for Undergraduate Pilot Training. A prototype TS-X will test the dome technique. Both of these techniques offer the capability of full-mission visual simulation.

<u>Summary</u>

The two simulator designs specified by the Mission Analysis Study represent a low risk approach to achieving the benefits of simulation. It will be established later in the report that the near-term application of TS-2 simulation will provide substantial training benefits and achieve significant cost savings. Furthermore, the projected benefits of TS-3 full-mission simulation provide real impetus to support the research efforts necessary to ensure its forecast implementation.

Future Trainer Aircraft

The new trainer aircraft were developed from a series of parametric analyses that defined the general aircraft characteristics in sufficient detail so that aircraft performance and cost could be reasonably estimated. The performance and equipment requirements thus derived are shown in Tables XV and XVI. The capability of the present UPT trainers, T-37 and T-38 with or without modifications, to meet these future aircraft requirements was also determined.

<u>Design Philosophy</u>

The design philosophy for the new trainer aircraft was to minimize downtime, turnaround time, support equipment, and operating cost. Such features as modular avionics and ground level access for maintenance supported this philosophy and were included in the designs.

Use of various composite materials was considered for reducing structural weight. The greatest potential for use of composites is in the high performance basic trainer aircraft. It was determined that weight saving structural composites are not expected to be employed to full engineering advantage until 1990 because of the high cost relative to aluminum. Consequently, aluminum structures were used for the airframes of new flight trainer candidates.

Representative missions were established for the Primary, Basic Fighter, and Basic transport/bomber trainer aircraft in order to determine the fuel requirements for the trainers. The representative mission fuel allowances were then compared to that required for the various trainer missions (instrument, navigation, etc.) to ensure its adequacy. The representative missions chosen for the new trainer aircraft are listed below.

TABLE XV

FUTURE TRAINER AIRCRAFT -- PERFORMANCE REQUIREMENTS

Design Parameter	Primary Aircraft	Basic Trainer Aircraft: Fighter	Basic Trainer Aircraft: Transport/Bomber
Takeoff Ground Run, feet	≤ 4,000	≤ 4,000	≤ 4,000
Takeoff Time, seconds	10-15	10-15	10-15
Landing Ground Roll, feet	≤ 4,000	≤ 4,000	≤ 4,000
Approach Speed, knots	90-110	110-135	90-110
Rate of Climb (nominal mission conditions), fpm	≥ 2,000 (15,000 ft altitude)	≥ 8,000 (15,000 ft altitude)	≥ 2,000 (15,000 ft altitude)
Single Engine Rate of Climb, fpm (hot day, takeoff configuration)	≥ 400	≥ 1,000	≥ 400
Endurance in Cruise Phase, hours (for representative mission)	1.5 hrs at 250 kts cruise at 15,000 ft	2.0 hrs @ M=0.8 cruise at 36,000 ft	2.9 hrs @ M=0.55 cruise at 30,000 ft
Cruise Ceiling, feet	≥ 25,000	≥ 45,000	≥ 30,000
Sustained Load Factor, gs	≥ +2.5 at 15,000 ft	≥ +4.0 at 15,000 ft	≥ +2.5 at 15,000 ft
Instantaneous Load Factor, gs	≥ +4.0 at 15,000 ft	≥ +7 at S.L. ≥ +6.0 at 15,000 ft	≥ +3.0 ‡
Life Expectancy, flt hrs	15,000	15,000	18,000
Maximum Speed, knots/Mach	Fallout but ≥ 250 knots	Fallout but high subsonic	Fallout but ≥ M=0.55
Handling Qualities	Highly Spin Resistant and Excellent Handling	Same	Same ‡

* Be able to operate at 500-feet above ground level at 200-250 knots.

‡ The transport/bomber roll rates should be commensurate with large operational transport/bomber aircraft. Also, include sufficient adverse yaw to require use of rudder.

TABLE XVI

FUTURE TRAINER AIRCRAFT -- EQUIPMENT REQUIREMENTS

Design Parameter	Primary Aircraft	Basic Trainer Aircraft	
		Fighter	Transport/Bomber
Avionics -- Communications	UHF, Hot Mike Intercom	Same	Same
Avionics -- Navigation	TACAN or VOR-DME, Area Nav., IFF/SIF (AIMS), U.S. Marker Beacon	Same	Same
Avionics -- Special	Collision Avoidance	Weather & Ground Map Radar, Depressible Gunsight, Collision Avoidance	Collision Avoidance
Instruments -- Engine	Conventional State-of-the-Art Round Dial	Same	Vertical Scale
Instruments -- Flight	Attitude, Heading Reference Sys, Flight Director, Angle of Attack Indicator	Same	Same
Status Monitoring	Conventional Light Warning	Same	Same
Student Performance Measurement Equipment	Audio Video Recording System, Audio Tape Recorder	Same	Same
Air Conditioning	Provide	Provide	Provide
Birdproof Windshield	Provide	Provide	Provide
Windshield, Engine Anti-Ice	Windshield, Inlet & Guide Vane Anti-Icing	Same	Same
Windshield Wipers Defoggers	Defoggers	Defogger	Defoggers
Oxygen & Pressurization	Provide	Provide	Provide
Zero/Zero Escape System	Provide	Provide	Conventional Bailout Escape
Standard Emergency System	Provide	Provide	Provide

Primary Trainer Aircraft:

Takeoff = 10 minutes idle + five minutes MIL power

Climb = MIL power climb to 15,000 feet

Cruise = 1.5 hours at 250 knots TAS at 15,000 feet

Landing = 15 minutes MIL power at sea level

Reserves = 20 minutes loiter at sea level

(five percent fuel tolerance allowed for mission)

Basic Fighter Trainer Aircraft:

Takeoff = 10 minutes idle + two minutes MIL power

Climb = MIL power climb to 36,000 feet

Cruise = two hours at M = 0.8 at 36,000 feet

Landing/Reserves = 20 minutes loiter at sea level

(five percent fuel tolerance allowed for mission)

Basic Transport/Bomber Trainer Aircraft:

Taxi = 10 minutes at idle

Takeoff/Climb = 10 minutes MIL power to 30,000 feet

Cruise = three hours at M = 0.55 at 30,000 feet

Descent = 10 minutes at idle

Traffic Patterns = 15 minutes MIL power

Landing Reserve = 20 minutes loiter at sea level

(five percent fuel tolerance allowed for mission)

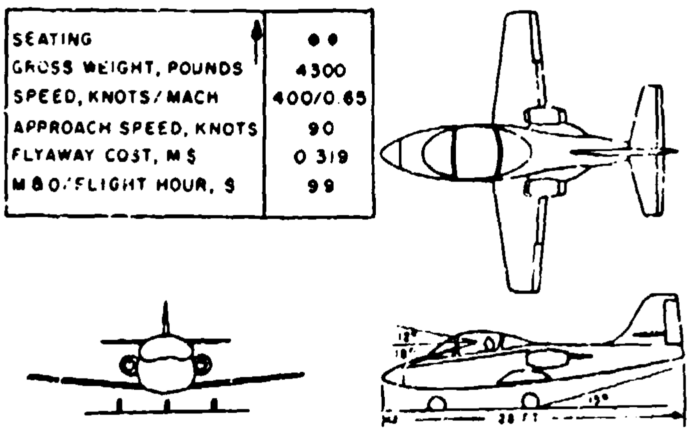
Initially a large number of conceptual aircraft were identified and matched against training requirements. Many concepts fell out in this process due to overdesign, high cost or questionable feasibility for UPT type flying. As an example, all supersonic capable aircraft were rejected because training requirements did not identify the need for a supersonic trainer.

Particular attention was devoted to trainer aircraft with a third seat designed specially for a student to "dynamically observe." It was found that the added cost of this special requirement could not be justified based on the possible benefits to be derived by employing the dynamic observer concept. Analysis was also made of several light propeller aircraft for use as primary trainers. One such aircraft was identified (designated TA-1) and initial training analysis and course design were accomplished. However, this training option was eliminated from consideration in the evaluation process. As a result, a propeller aircraft is not included in any of the final system options. Finally, such aircraft design features as variable stability and variable geometry were examined and found to be unnecessary in a UPT trainer -- both from the standpoint of cost and training requirements.

New Trainer Aircraft

Three new aircraft were identified from this analysis: a primary jet trainer designated TA-2, a basic jet trainer designated TA-3, and a basic multiengine jet trainer designated TA-4. Each of these aircraft are described below. The TA-1 designation was used to identify a light propeller driven primary aircraft. This candidate aircraft will not be described because the system employing it was eliminated as a viable system option. The reasons for this elimination will be presented later in the report.

The TA-2 is a low wing, two-place, side-by-side primary trainer powered by twin turbofan engines and utilizing a single straight wing planform which provides a good low speed flight characteristic. A trailing edge slotted flap is used. Construction is conventional aluminum structure. A three-view drawing of this aircraft is shown in Figure 23.



SEATING	● ●
GROSS WEIGHT, POUNDS	4300
SPEED, KNOTS/MACH	400/0.65
APPROACH SPEED, KNOTS	90
FLYAWAY COST, M $	0.319
M & O/FLIGHT HOUR, $	99

Figure 23. Two Place Primary Trainer Aircraft

The engine, representative of a derivative from the Garrett TFE 231-P13 74 turbofan, is a 1000-pound thrust, two-spool counter-rotating turbofan with a bypass ratio of 2.5. Other engine characteristics are: engine thrust to weight of 7.0, compressor pressure ratio of 14 to 1, turbine inlet temperature of 2200°F, and specific fuel consumption of 0.54 pound of fuel per hour per pound of thrust. The engine is approximately 26 inches long and 13 inches in diameter. Development of the engine is within the state of the art. A comparison of performance characteristics versus the primary aircraft requirements is shown in Table XVII. The performance characteristics were dictated by the thrust to weight (0.40) required for single-engine rate of climb (hot day at takeoff configuration) of 400-feet per minute and the sustained load factor of +2.5 gs at 15,000 feet altitude. The maximum speed of 400 knots/m = 0.65 was a fallout of the thrust per weight ratio. The wing loading (40-pounds per square foot) was dictated by the sustained load factor. Facility and manpower requirements to support this aircraft should be approximately the same as for the T-37.

The TA-3 is a two-place, tandem basic-fighter trainer power by twin turbofan engines, utilizing a moderately swept wing planform with trailing-edge single slotted flaps, and a slender fuselage with conventional tail surface. Construction is conventional aluminum structure. A three-view illustration of this aircraft is shown in Figure 24.

The turbofan propulsion system specified for this design would be the pacing item in the aircraft development. A new engine development program would be required. The engine characteristics are: 4000 pound thrust, engine thrust to weight of 9.0, bypass ratio of 6.5, compressor pressure ratio of 18 to 1, turbine inlet temperature of 2500°F, and a specific fuel consumption of 0.36 pound of fuel per hour per pound of thrust. The engine is approximately 29 inches long and 37 inches in width. Component development (fan and turbine inlet temperature) and development and test of a demonstrator engine will be necessary to achieve this TF-39 (C-5A engine) technology in a low-thrust small-size turbofan engine.

A comparison of performance characteristics versus the basic fighter trainer aircraft requirements is shown in Table XVIII.

TABLE XXVII

PRIMARY TRAINER AIRCRAFT PERFORMANCE

Design Parameter	Design Requirements	Primary Trainer
Seating ↑ FWD	● ●	● ●
Takeoff Ground Run, feet	≤ 4,000	1,000
Takeoff Time, second	10-15	12
Landing Ground Roll, feet	≤ 4,000	1,500
Approach Speed, knots	90-110	90
Rate of Climb (nominal mission conditions), fpm	≥ 2,000 at 15,000 feet	2,400
Single Engine Rate of Climb (hot day takeoff configuration), fpm	≥ 400 at S.L.	400
Endurance in Cruise Phase, (for representative mission), hours	Sufficient for Missions 1.5 hr. cruise at 250 knots at 15,000 feet	1.5
Cruise Ceiling (300 fpm R/C) normal power, feet	25,000	31,000
Sustained Load Factor, gs	≥ 2.5 at 15,000 feet	2.5
Instantaneous Load Factor, gs	≥ 4.0 at 15,000 feet	6.0
Life Expectancy, flight hours	15,000	15,000
Handling Qualities	Highly spin resistant & excellent handling	Provided
Max Speed, knots/Mach	250 knots	400/0.65
Empty Weight, pounds		2,965
Usable Load, pounds		1,335
Gross Weight, pounds		43,000

SEATING	••
GROSS WEIGHT, POUNDS	8400
SPEED, KNOTS/MACH	600/0.95
APPROACH SPEED, KNOTS	110
FLYAWAY COST, M$	0.792
M & O/FLIGHT HOUR, $	150

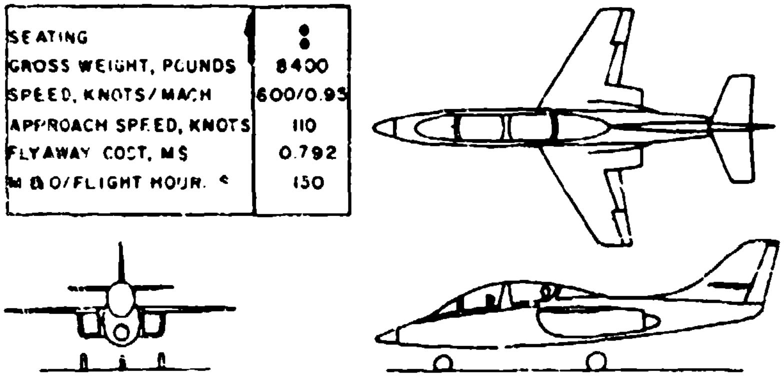


Figure 24. Two Place Basic Fighter Trainer Aircraft

The performance characteristics were dictated by the thrust to weight (0.80) required for a sustained load factor of +4.0 gs at 15,000 feet altitude. The maximum speed of 600 knots/M = 0.94 was a fallout of the thrust to weight ratio. The wing loading (50 pounds per square foot) was dictated by the sustained load factor and approach velocity requirements.

The facilities and manpower required to maintain this aircraft should be slightly less than that required for the T-38.

The TA-4 is a trainer aircraft with side-by-side seating in front and a fold-down seat located in the cabin entrance on the centerline which will accommodate one instructor pilot and two students on a training flight. The low wing has low sweep and slotted flaps. Construction is conventional aluminum. A three-view illustration of this aircraft is shown in Figure 25. Two turbofan type engines, representative of a derivation from the Lycoming ALF-301B engine, are mounted on the aft fuselage.

The primary role of this aircraft will be as a trainer. Potential fallout benefits could be to transport parts and maintenance personnel to locations where other UPT aircraft are out of commission for maintenance. Thus, the cabin is large enough and has an entrance door to enable loading and transporting of future trainer aircraft engines. The cabin is sized by the J-85 for length and weight and the transport/bomber trainer engine for maximum diameter. In addition, provisions were made for removable passenger seats in the cabin. The engine is a 2900 pound thrust, two-spool, counter-rotating turbofan with a bypass ratio of 5.6. Other engine characteristics are: engine thrust to weight of 4.6, turbine inlet temperature of 1975°F, and a specific fuel consumption of 0.44 pound of fuel per hour per pound of thrust. The engine is approximately 48 inches long and 29 inches in diameter. Development of the engine is within the state of the art.

SEATING	•••
GROSS WEIGHT, POUNDS	12,600
SPEED, KNOTS/MACH	400/0.75
APPROACH SPEED, KNOTS	110
FLYAWAY COST, M$	0.617
M & O/FLIGHT HOUR, $	135

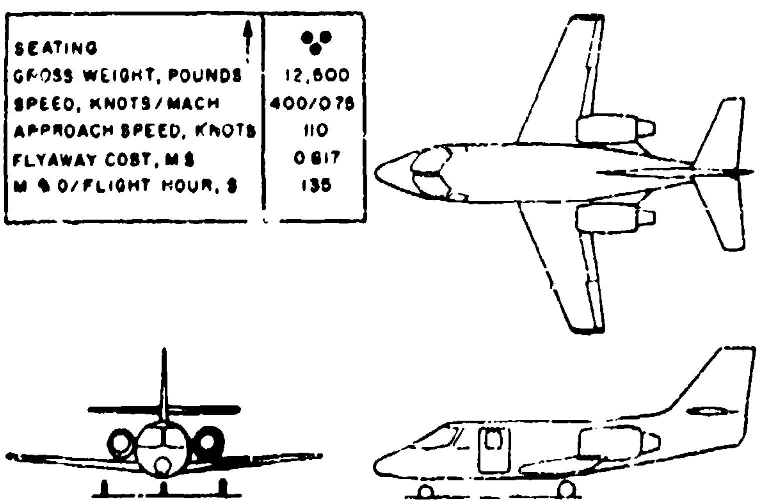


Figure 25. Basic Bomber/Transport Trainer

Facility and manpower requirements to support this aircraft should be approximately the same as for the T-38. A comparison of the performance characteristics versus the Transport/Bomber aircraft requirements is shown in Table XIX. The performance characteristics were dictated by the thrust to weight (0.46) required for a sustained load factor of 2.5 gs at 15,000 feet altitude. The maximum speed of 440 knots/M = 0.75 was a fallout of the thrust-to-weight ratio. The wing loading (60 pounds per square foot) was dictated by the sustained load factor and approach velocity requirements.

TABLE XVIII

BASIC FIGHTER TRAINER AIRCRAFT PERFORMANCE

Design Parameter	Design Requirements	Basic Fighter Trainer
Seating FWD ↑	● ●	● ●
Takeoff Ground Run, feet	≤ 4,000	800
Takeoff Time, second	10-15	10
Landing Ground Roll, feet	≤ 4,000	1,600
Approach Speed, knots	110-135	110
Rate of Climb (nominal mission conditions), fpm	≥ 8,000 at 15,000 feet	8,800
Single Engine Rate of Climb (hot day, takeoff configuration) fpm	≥ 1,000 at S.L.	2,500
Endurance in Cruise Phase (for representative mission), hours	2.0 hr. cruise at 0.8 Mach at 36,000 feet	2.0
Cruise Ceiling (Mil power), feet	≥ 45,000	48,000
Sustained Load Factor, gs	≥ 4.0 at 15,000 feet	4.0
Instantaneous Load Factor, gs	≥ 1.0 at S.L., 6.0 at 15,000 feet	7.3 at 15,000 feet
Life Expectancy, flight hours	15,000	15,000
Handling Qualities	Very good	Provided
Max Speed, knot/Mach	Fallout but high subsonic	600/0.94
Empty Weight, pounds		6,330
Usable Load, pounds		2,070
Gross Weight, pounds		8,400

TABLE XIX

BASIC TRANSPORT/BOMBER TRAINER AIRCRAFT PERFORMANCE

Design Parameter	Design Requirement	Basic Transport/ Bomber Trainer
Seating TWO		
Takeoff Ground Run, feet	≤ 4,000	1,650
Takeoff Time, seconds	≤ 10	12
Landing Ground Roll, feet	≤ 4,000	1,460
Approach Speed, knots	90-110	110
Rate of Climb, fpm at 15,000 feet	≥ 2,000	3,100
Single Engine Rate of Climb (hot day takeoff configuration) fpm	≥ 400 at 15,000 feet	785
Endurance in Cruise Phase (for representative mission), hrs	3.0 hr. cruise at altitude plus reserves	3.0 (cruise at 15,000 feet)
Cruise Ceiling, feet	30,000	40,500
Sustained Load Factor, gs	+2.5 at 15,000 feet	+2.5
Instantaneous Load Factor, gs	1	+4.3
Life Expectancy, flight hours	10,000	15,000
Handling Qualities	Highly Spin Resistant & Excellent Handling	Provided
Maximum Speed, knots/Mach	M ≥ 0.55	440/.75
Empty Weight, pounds Useful Weight, pounds Gross Weight, pounds		7,775 4,560 12,705

*To be able to operate at 500 feet above ground level at 200-250 knots.

Current Trainer Aircraft

The T-37 and T-38 trainer aircraft have considerable design life remaining. The T-37 entered the inventory in 1958 and the last aircraft was delivered in 1966. The average T-37 has accumulated about 5,000 flying hours out of a design life of 15,000 flying hours. The T-38 entered the inventory in 1961 and the last aircraft was scheduled for delivery in early 1972. The average T-38 has accumulated about 3,000 flying hours out of a design life of 16,000 flying hours. These average flying hours were determined by an aircraft life expectancy analysis made using the "Equipment Life Expectancy Model" (to be discussed later).

The T-37 and T-38 design life of 15,000 and 16,000 flying hours, respectively, are based on information received from the T-37 and T-38 Program Offices.

In view of the substantial number of flying hours remaining for both the T-37 and T-38, they are viable trainer aircraft candidates along with the new conceptual trainer aircraft noted above. The ability of the T-37 and T-38 to meet the Future Undergraduate Pilot Training trainer aircraft requirements was examined. Where the T-37 or T-38 did not meet these future aircraft requirements, possible modifications were considered. The T-37 three-view illustration is shown in Figure 26.

SEATING	[illegible]
GROSS WEIGHT, POUNDS	6700
SPEED, KNOTS/MACH	380/0 57
APPROACH SPEED, KNOTS	100
FLYAWAY COST, M$	[illegible]
M&O/FLIGHT HOUR, $	105

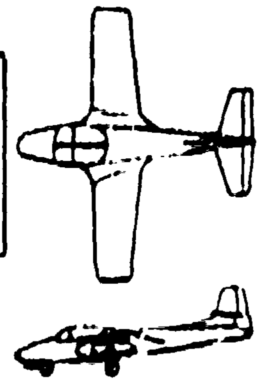


Figure 26. Two Place Primary Trainer Aircraft, T-37

The feasibility of modifying the T-37 to better meet the future aircraft requirements was determined by the T-37 Project Office at the San Antonio Air Materiel Area. Analysis showed that the two performance area deficiencies (single engine rate of climb and cruise endurance) could not be corrected without a major modification program. The magnitude of these performance deficiencies do not warrant the cost of a major modification and are considered acceptable based on the safety of operation achieved by the T-37 today. The avionics equipment deficiencies included Distance Measuring Equipment, AIMS, Instrument Landing System, Audio-Visual Recording System, Area Navigation and Collision Avoidance. It was determined that the T-37 could accommodate these avionics and the cost of this equipment was included in the overall system option costs. The DME, AIMS, and AVRS have already been programmed by ATC for the T-37. Incorporation of these avionics equipments will significantly improve the ability of the T-37 aircraft to operate in the future Airspace Structure. The T-38 three-view illustration is shown in Figure 27.

SEATING	[illegible]
GROSS WEIGHT, POUNDS	[illegible]
SPEED, KNOTS/MACH	[illegible]
APPROACH SPEED, KNOTS	[illegible]
FLYAWAY COST, M$	[illegible]
M&O/FLIGHT HOUR, $	[illegible]

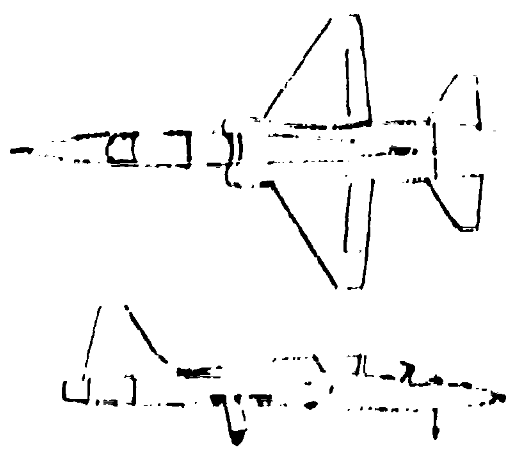


Figure 27. Two Place Basic Fighter Trainer Aircraft

The feasibility of modifying the T-38 to better meet the future aircraft requirements was determined by the T-38 System Project Office at the Aeronautical Systems Division. The analysis showed that the two performance deficiencies (approach speed and cruise endurance) could not be corrected without a major modification program. The magnitude of these performance deficiencies do not warrant the cost of a major modification and are considered acceptable based on the safety of operation achieved by the T-38 today.

The avionics equipment deficiencies included AIMS, Audio-Video Recording System, Area Navigation, and Collision Avoidance. It was determined that the T-38 could accommodate these avionics and the cost of the equipment was included in the overall system option costs. The AIMS has already been programmed by ATC for the T-38. Incorporation of these avionics equipments will significantly improve the T-38's ability to operate in the future airspace structure.

Summary.

The results of the aircraft analysis provided five future trainer aircraft -- the two current trainers, and three new trainers. These trainer aircraft are employed in different combinations to make up the future UPT system options that will be described later in the report.

DEVELOPMENT AND REFINEMENT OF ANALYTICAL TOOLS (APPENDIX Q)

It was critical to the Mission Analysis effort that well formulated models be designed to permit manipulation of key parameters and determine their overall system effect. The total UPT system is an extremely complex matrix with many dependent variables.

The models developed for the Mission Analysis synthesized for the first time these difficult interrelationships of the UPT system elements and provided timely data for evaluating the system options that will be discussed later in the report.

It is important to point out that the models themselves represent a significant contribution to the future management of Undergraduate Pilot Training. They will provide the Air Training Command with an increased capability to answer important questions about the impact of changes to the UPT program. Each of these models will now be described in general terms, and the importance of their products explained.

Equipment Life Expectancy Model

The Equipment Life Expectancy Model (ELEM) was the analytical tool used to investigate the capability of a given fleet of equipment (aircraft, flight instrument trainers and simulators) to support a variety of UPT systems.

The ELEM application was especially critical in the study process because it identified when the current trainer aircraft would be insufficient to support the different future UPT system options under consideration. The model thereby provided meaningful decision dates for new equipment purchases.

It is most important that the term insufficiency be clearly understood when aircraft fleet life is being examined. Insufficiency is defined as that date when the number of available aircraft become less than the number required to support necessary usage.

Upon further development of insufficiency, it is obvious that many variables have important impact on necessary usage and that the date of insufficiency by itself does not provide an adequate description of the fleet life expectancy.

For instance, a fleet becomes insufficient through aircraft loss, which has two sources -- aircraft lost through attrition (catastrophic loss) and aircraft lost through retirement (reaching design service life). The rate of loss due to aircraft attrition is much less than that due to retirement. Few, if any, aircraft crash in a given month, but many aircraft could reach their design service life in that time. Therefore, a system in which the date of insufficiency is reached before aircraft begin to retire is insufficient by only a small number of aircraft and accordingly is more sensitive to changes in flying requirements. For example, if a fleet of aircraft has an insufficiency date based on attrition, it may be possible to alleviate the shortage by a small increase in utilization rate.

However, retirement is more abrupt than attrition because it is a function of the rate of original procurement. For this reason, the beginning of retirement is considered the end of potential for that fleet. (If there are sufficient excess aircraft, a system can continue viably after retirement has begun, but generally for only a few months.)

From this explanation of insufficiency it can be seen that merely presenting the insufficiency date of a given aircraft fleet is only part of the story. A better way of presenting the results is to include some indication of the flying capability remaining in the system after the date of insufficiency. There are, therefore, several pieces of information that can be presented about each analysis of fleet life:

- Date of insufficiency
- Cause of insufficiency
- Time to onset of retirement
- Number of aircraft the system is deficient initially and at the time of initial retirement.

Naturally, distinctions on types of insufficiency for ground training equipment, such as simulators, are not necessary since no attrition loss factor is applied. As a result, insufficiency for ground training equipment is based on retirement only. From this information, one may determine when or if the system will be insufficient, how far the system can be extended until retirement finally limits the system, and the magnitude of the changes necessary to extend the system to retirement.

The inputs into the ELCM included all of the important variables that influence equipment fleet life. They are presented here in brief form to demonstrate the depth of analysis and establish credibility for the findings:

Syllabus ——

- Define as many categories of training as desired. Input the number of such categories.
- Assign the appropriate number of flying hours to each category and state how many months that number of flying hours will be needed. Input these flying hours and months for each category.
- Define levels of simulation that are to be investigated and the number of months that level is to be utilized.

Student Attrition ——

- Determine percentage of entering students who attrit in each phase.
- Determine how many hours in each phase are accumulated by students who attrit in the phase.

Other inputs are as follows: ——

- Number of graduates required in each year of operation
- Size of initial equipment inventory
- Number of hours accrued to date on each piece of equi[illegible] the inventory
- Service life limit for the equipment
- Rate of equipment attrition as a function of usage
- Maximum utilization rate of the equipment

- Other (overhead) uses of the equipment

- Number of months in which procurement occurs and the number of pieces of equipment procured in each month.

All of the inputs to this model are variable to some degree and it is useful to know the relative impact of each variable on the equipment life being considered. Several important points on sensivity of required aircraft numbers were derived for the current trainer aircraft:

- The variables that cause the greatest change in date of insufficiency are <u>graduate production</u> and <u>curriculum hours</u>.

- All variables have a greater effect on the T-37 date of insufficiency than on the T-38 date of insufficiency. The rate of T-38 aircraft loss is considerably greater than the T-37 rate, due to greater attrition, so an equal change to the two fleets will have less effect in the T-38 case.

- Retirement is an important factor for the T-37 fleet but is not important to the T-38 fleet.

The detailed findings of the ELEM are presented later in the report when the alternative system options are examined. However, several important general conclusions provide an overall understanding of the life span of the current training equipment and serve to summarize this section on the ELEM. They are:

- The modeling approach as described here provides much valuable information about the adequacy of a given fleet of equipment to support a particular training requirement.

- Consideration of the date at which the aircraft fleet becomes insufficient is not of itself an adequate description of the sufficiency of any system. Further considerations necessary are the cause of insufficiency (attrition or retirement), the length of time remaining to retirement, and the aircraft deficiency at retirement.

- Because the exact date of insufficiency is sensitive to many factors, use of a single date is less satisfactory than the use of a range of dates.

- The data base on the instrument flight trainers used in UPT was inadequate to determine a firm date of insufficiency. However, the instrument flight trainers should become insufficient in the vicinity of 1980 for the current syllabus.

<u>UPT System Model</u>

The UPT system model is a resource requirements model and was the primary analytical tool used during the Mission Analysis to evaluate alternative training systems. The model was derived from one of two contracted system studies that required construction of mathematical models of the UPT system.

The general flows of the system model are presented in Figure 26. The six major parts of the model are:

1) <u>The Control Module</u>
2) The training requirements Allocation Module
3) <u>The Total System Cost Module</u>
4) <u>The Permanent Data File</u>
5) The Equipment Utilization Capability Module
6) The Pilot Inventory Module.

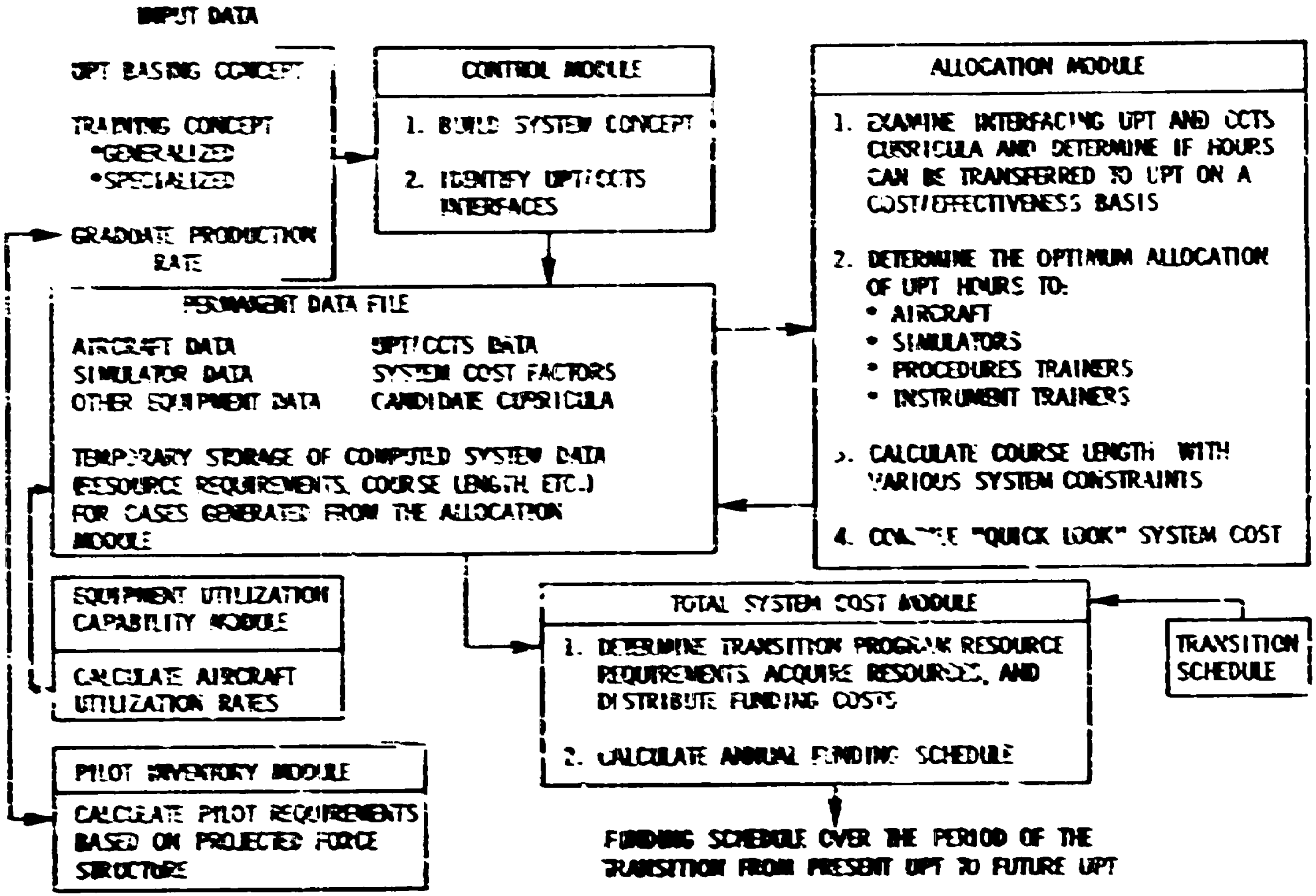


Figure 23. UPT System Model

The Control Module transfers basic information concerning training concepts into computer storage for immediate or later use. This information includes such items as flying hours, number of bases, and the aircraft used in training.

The Allocation Module is made up of two submodules: The UPT/CCTS interface submodule and the training element allocation submodule. The former submodule examines the overall cost impact of transferring a training objective from CCTS to Undergraduate Pilot Training. This analysis is based upon such factors as the aircraft operating costs in UPT and CCTS, the number of flying hours required to do the task in UPT versus CCTS, and the cost of adding required avionics to UPT aircraft. The latter submodule examines the cost of performing training in the aircraft or alternative types of simulators and cockpit procedures trainers. Training hours are then allocated to these various equipment types on the basis of cost advantage and training capability.

The Cost Module estimates the resource and dollar requirements of operating a training system over a period of up to 30 years. The costing may include fairly detailed transition steps from one system to another. This module will be discussed in more detail in the following subsections.

The Permanent Data File consists, as the name implies, of almost all the data that are used repeatedly by the UPT System Model. This information includes personnel cost factors, factors describing the maintenance and operating of equipment, and training systems characteristics input via the Control Module. The Permanent Data File is primarily used by the Cost Module and the training requirements allocation Module.

The Equipment Utilization Capability Module analyzes the design characteristics of an aircraft along with policies concerning its operation to determine probable utilization rates. This module would be run separately for a proposed aircraft to determine the utilization rates that would go into the Permanent Data File.

The Pilot Inventory Module primarily predicts future UPT graduate requirements.

Of the different modules available, only the Cost Module, Control Module, and Permanent Data File were ultimately employed. The other modules were not employed because their information was either not needed for the purposes of the analysis, or more accurate information than the module could produce was obtained from other sources. However, the modules not used for the Mission Analysis may be useful for ATC future planning activities (Hq ATC has the complete model program).

Model Validation

Although the advantages of computer simulation and use of the modeling approach in studies of this nature are generally accepted in the Air Force today, concern for the accuracy of specific models still exists. An early objective of the UPT Mission Analysis was to evaluate the accuracy and validity of the UPT system model. The approach taken for validation was to subject the model to a two-fold review. First, the model was reviewed in a subjective manner and then tested objectively to determine the proximity of simulated cost to the actual recorded expense of an existing system. The subjective analysis was accomplished in the following manner:

- The sequence of cost development steps was reviewed to determine if the proper cause and effect relationships were maintained.
- The documentation of the module was also reviewed to identify the variables employed to compute costs.
- The logic incorporated into the various estimating equations was evaluated to determine if they conformed to cost behavior patterns known to exist.

Based on this analysis, it was concluded that the model included all significant variables and was accurately programmed. Therefore, it was hypothesized that the model would simulate the costing of existing or hypothetical UPT systems, and furthermore the degree of accuracy experienced in costing the existing UPT system would indicate the accuracy to be expected in costing alternative UPT systems.

The objective test of this hypothesis was accomplished by costing the FY 1970 UPT program and comparing the results to those compiled by Air Training Command. The UPT system model incorporates several cost items not included in ATC accounting records. Therefore, it was necessary to reconcile the system model results with the accounting data and compare reconciled results. Reconciliation was necessary in the following areas:

- Replacement training of personnel
- Permanent change of station travel
- Depot maintenance
- Replenishment spares
- Recurring modification
- Production level adjustments
- Economic price level (inflation).

After incorporating the reconciliation items, the actual costs were compared with the cost derived using the UPT system model. The overall difference in operating cost was 0.8 percent.

Some internal offsetting differences can be attributed in part to accounting inconsistencies between the UPT systems model and the actual ATC records. However, some of the variance can be explained by the fact that in 1970 the UPT program was operated below certain requirement levels. For example, there is a common variance between actual cost and model output cost manifested in the T-37 and T-38 flight training phase (see Tables XX and XXI). The model output costs are significantly higher than actual costs. This variance is explained by the fact that in FY 1970, the manning level of instructor pilots was considerably below normal. Therefore, actual costs reflect that situation. The model output costs on the other hand reflect the required instructor manning level cost. In this particular example, the excess of the model output actually substantiates its validity.

TABLE XX

UPT COMPARATIVE OPERATING COSTS, T-37 PHASE
(ACTUAL COST VS COST MODEL OUTPUT -- 240 HOUR CONCEPT)

Item	Accounting Reports, $000	Model Output, $000
T-37 Phase		
Student Pay	$17,280	$16,326
Flight Training	12,145	17,919
Simulator Training	1,384	1,593
Academy/Officer Training	2,377	2,457
Aircraft Maintenance	17,671	16,389
Other Equipment Costs	36,374	34,992
Overhead, Tenants, Miscellaneous	7,142	6,372
Phase Total	$94,373	$96,048

TABLE XXI

UPT COMPARATIVE OPERATING COSTS, T-38 PHASE
(ACTUAL COST VS COST MODEL OUTPUT -- 240 HOUR CONCEPT)

Item	Accounting Reports, $000	Model Output, $000
T-38 Phase		
Student Pay	$ 21,982	$ 20,898
Flight Training	15,027	19,989
Simulator Training	1,509	1,656
Academy/Officer Training	3,011	2,925
Aircraft Maintenance	36,146	33,840
Other Equipment Costs	94,057	88,398
Overhead, Tenants, Miscellaneous	13,017	7,929
Phase Total	$184,749	$175,635

Summary

In view of the outcome of the comparison with actual cost data it was concluded that the UPT system model simulates the costing of the existing program with reasonable accuracy and will be a satisfactory analytical tool for the evaluation of alternative future UPT systems.

Simplified Cost Model

The Simplified Cost Model (SCM) was designed and developed for the purpose of conducting sensitivity analysis on the key factors that influence UPT cost. The UPT system model could not be applied effectively for this purpose because it was designed for deriving transition plans and detailed costing. Much of the output of this large model was unnecessary for the purpose of sensitivity analysis.

Actually, the Simplified Cost Model (SCM) is a derivative of the UPT system model with factors affecting transition plans removed. The SCM requires only 4000 units of computer memory compared to the 45,000 units required for the UPT system model. However, all the costs considered in the UPT System Model are also considered in the Simplified Cost Model.

The results of the SCM and the UPT System Model are within one percent of one another. Therefore, the SCM was considered an accurate analytical tool for determining sensitivity.

The results of the sensitivity analysis using the SCM will be given later in the report when the evaluation of the alternative future UPT system options is presented.

DEFINITION OF ALTERNATIVE FUTURE UPT SYSTEMS (APPENDIX H)

The alternative Future UPT systems described in this section represent the best combinations of the training concepts and training equipment that up to this point have been described independently. Each of the options is designed to accomplish the training requirements identified for the given system.

It is important to recognize that the Systems Approach to Training concept (SAT) does not allow for a major change in one system element without having an effect on the rest of the system. Therefore, if changes are to be made to the system options presented here, a complete revaluation will be necessary to determine the effect of the change.

Reduction of System Options

Initially, the combination of training requirements, training concepts, and training equipment produced 14 systems. These 14 systems were grouped into three overall concepts as shown in Figure 29. From these curriculum concepts, it can be seen that training

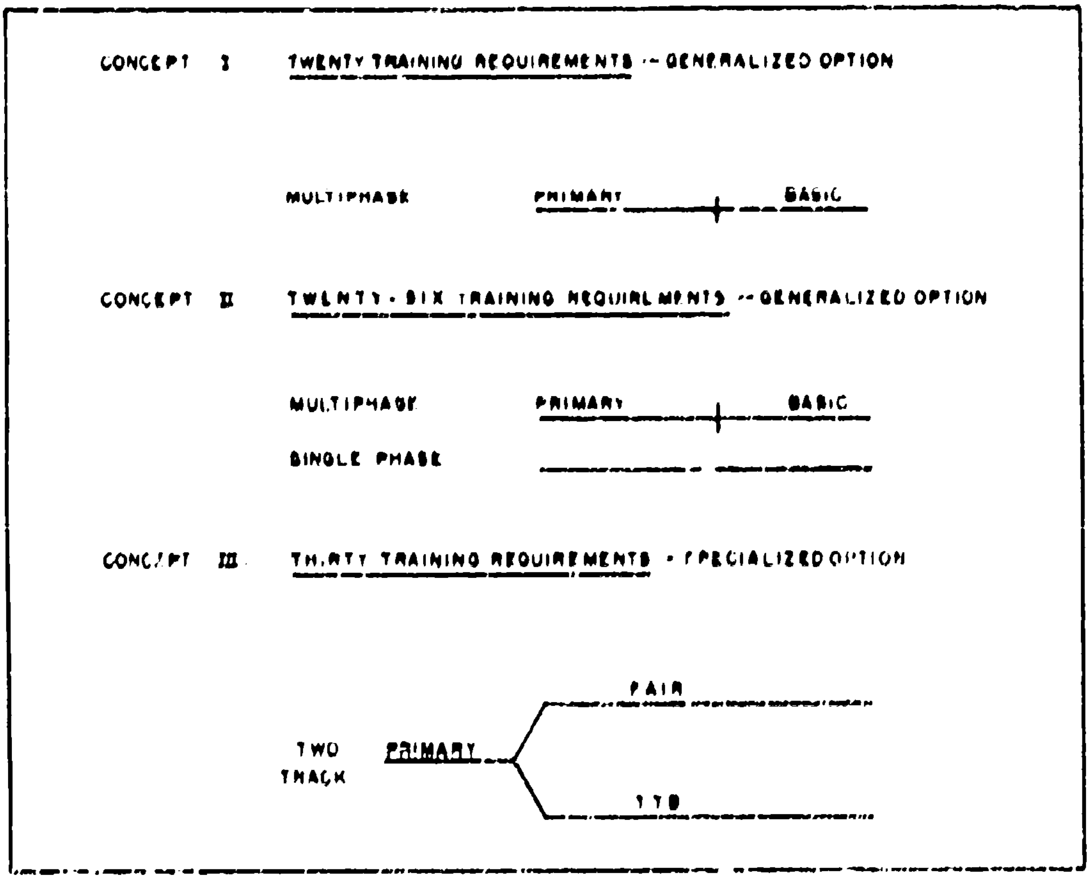


Figure 29. Curriculum Concepts

requirements on Future UPT drive the choice of generalized or specialized curriculum options in the same manner they drive the choice of training hardware. The finding that it is not economically feasible to train all 30 future training requirements in a generalized training system was deduced from the commonality criteria used in the selection of training requirements. The criteria were based on the numbers of pilots requiring skill in the performance of a particular task and whether or not the task was sufficiently common across operational aircraft to be considered a single task. Therefore, the training requirements were categorized by their degree of commonality. Tasks required by all pilots had the highest degree of commonality and, thus, are generalized. Conversely, those required by fewer pilots had a lower degree of commonality and are specialized. Therefore, if all 30 training requirements were taught to all students in a generalized UPT, many students would receive training in some tasks which would not be used in their initial operational assignments.

Training requirements were used to illustrate the commonality continuum from the 20 training requirements taught in the current generalized UPT program to 26 requirements identified for future generalized systems, and, finally, to 30 requirements which may be introduced economically if specialized training is adopted in Future Undergraduate Pilot Training. The task commonality analysis provided evidence that 26 training requirements is the likely break point between generalized and specialized training systems. If 26 or less are adopted, generalized training is justified. If more than 26 are adopted, specialized training should be employed. It follows that a graduate who had acquired more of the skills necessary in the performance of his operational duties is of higher quality than one who had acquired a fewer number of required skills. Therefore, quality implications can be tied to the number of training requirements incorporated in a particular UPT system option. These considerations are illustrated in Figure 30.

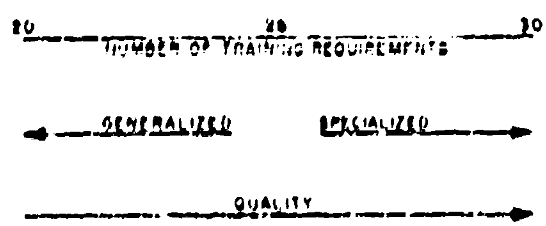


Figure 30. Commonality and Quality Continuum

Table XXII shows the 14 initial candidates system options with the aircraft employed in each system. All of the aircraft have been previously identified. In the initial phase of evaluating the 14 system options, transition plans for each of the systems were examined to test their feasibility.

The following ground rules were established for the system transition process:

- Use the current equipment -- this ground rule was an expression of the reality that new equipment cannot be justified when current equipment is adequate. The adequacy in numbers of the current trainer aircraft was determined by the life expectancy model described earlier.

- Compliance with system acquisition directives -- this rule ensured realistic guidelines on the amount of time required for new systems to come into the inventory. A go-ahead decision date of January 1973 for all new equipment was assumed.

- Operational before 1993 and usable through 1990 -- systems must meet this criteria to stay within the time frame of interest. Exceeding this forecast limit greatly reduces the validity of the force structure projections and makes prediction of the training requirements extremely difficult. Applying these ground rules to the 14 system options produced the distribution shown in Table XXIII and resulted in eight viable system options. Of these eight, two systems (Concepts II-E and III-E) employed a light propeller driven primary aircraft. These two candidate systems were rejected at this point in the analysis for operational reasons even though preliminary costing

showed them to be attractive. The following major arguments were the basis for rejection:

- The light propeller aircraft is limited in the amount of training it can provide. This is due to its low performance characteristics and low operating ceiling. If the aircraft is increased in performance, it loses its cost advantage.

- Operation of the light propeller aircraft in Future UPT will be more difficult than the all-jet approach. The propeller aircraft will be operating below 10,000 feet for all its missions, and will have to face the increasing civilian traffic projected by the FAA for the low altitude structure. In addition, the tremendous disparity in performance between the prop-primary trainer and the basic jet trainer complicates the operational problem. With rejection of the prop-primary systems, six viable system options remained and they were subjected to further detailed analysis using the UPT system model.

TABLE XXII

FUTURE UPT SYSTEM OPTIONS

Generalized (20 Training Requirements)	Primary A/C	Basic A/C General	Basic A/C FAIR	Basic A/C TTB
Concept I Prim Basic I-A	T-37	T-38		
Generalized (26 Training Requirements)				
Concept II Prim Basic II-A	T-37	T-38		
B	TA-2	T-38		
C	T-37	TA-3		
D	TA-2	TA-3		
E	TA-1	T-38		
F	TA-1	TA-3		
Single Phase G	TA-3	TA-3		
Specialized (30 Training Requirements)				
Concept III Prim {FAIR, TTB} III-A	T-37		T-38	TA-4
B	TA-2		T-38	TA-4
C	T-37		TA-3	TA-4
D	TA-2		TA-3	TA-4
E	TA-1		T-38	TA-4
F	TA-1		TA-3	TA-4
Total 14 UPT System Options for Evaluation				

TABLE XXIII

ALTERNATIVE SYSTEMS ANALYSIS

Concept	Number of Training Requirements	Column 1 Impractical Combinations	Column 2 Operational Post 1990	Column 3 Possible Options
I	20			A. T-37/T-38
II	26	C. T-37/TA-3	D. TA-2/TA-3 F. TA-1/TA-3	A. T-37/T-38 B. TA-2/T-38 E. TA-1/T-38 G. TA-3
III	30	C. T-37/TA-3/TA-4	D. TA-2/TA-3/TA-4 F. TA-1/TA-3/TA-4	A. T-37/T-38/TA-4 B. TA-2/T-38/TA-4 E. TA-1/T-38/TA-4

- Column 1, two options are impossible because the T-37 will not last until the new aircraft acquisition is justified.

- Column 2, four options cannot be achieved until post-1990 because the new equipment combinations cannot be justified before that time due to the life of the T-38.

- Column 3, eight viable system options remained that satisfy the initial ground rules.

System Option Description

Each of the Future UPT system options will now be described in detail. Curriculum design, curriculum, equipment, facilities, and personnel requirements will be presented for all systems. Before addressing each of these areas, it is necessary to point out that all of the training improvements described earlier in this report are applied to all system options. For purposes of review, these training improvements are:

- Reduced Training Rate
- Learning Center
- Training Manager
- Student Management
- Centralized Student Selection
- Student Evaluation
- Dynamic Observer.

Simulation is also applied to all system options, but it will be addressed separately because of its large impact.

Curriculum Design

The purpose of this section is to show the process used to find the training time for each system option. Included in this section is the rationale used for the substitution of simulation time for aircraft time. Figure 31 shows a format worksheet used to determine the amount of time necessary.

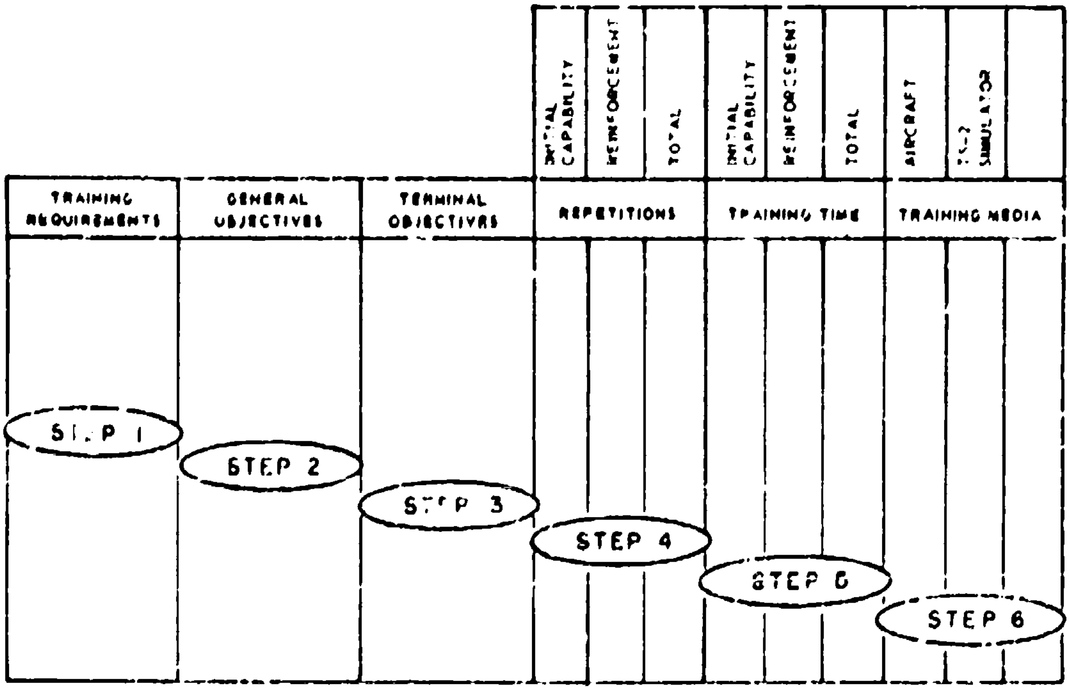


Figure 31. Sample Worksheet

- Step 1 was accomplished by the task and commonality analysis.

- Step 2 was to determine those training objectives for which a specific amount of training time could not be identified. As an example, formation discipline is an important training objective, but it is a resultant one achieved by cumulative training in other training events. Identifying these objectives in this manner provided insight into the amount of training that would be required in a total mission context.

- Step 3 was to list all of the training maneuvers that could be clearly defined in terms of time required to execute.

- Step 4 was to estimate the average number of times a student needed to practice a given task to reach an initial capability and how many times he needed to practice the task for reinforcement to reach proficiency. These estimates were made from empirical data, where possible. For example, actual averages were obtained from UPT bases for the number of instrument approaches and number of landings. Experienced judgments were made on the number of repetitions required for the other training maneuvers since actual data were not available.

- Step 5; the number of repetitions thus derived were multiplied by the amount of time required for each event. This was a straightforward process. However, some training events, such as straight and level flight were known to have a large amount of reinforcement time. This was a reflection of certain inefficiencies that result in the conduct of an aircraft mission. For example, the requirement to fly straight-and-level to go to-and-from the training area is not a training requirement after the student has

mastered straight-and-level flight. It is an operational requirement for which you must pay a training penalty. Reflecting these operational realities was accomplished by summing up the time required to accomplish all the training events, assuming perfect mission efficiency. The number of missions necessary to fly this amount of time was estimated and a straight-and-level requirement of 10 to 15 minutes per mission was added to the overall time. With this, the total amount of flying time required to train the student was determined.

- Step 6; the final important process of assigning training time to the different training media -- the aircraft and/or the simulator.

The evaluation process examined the training requirements for each of the major phases in the pilot training program -- instruments, contact, formation, and navigation. The selection of training media for each of the phases was determined to be the aircraft and/or the TS-2 simulator for the instrument phase and the aircraft and/or the TS-3 simulator for the contact, formation, and navigation phases. These two groupings of training media will now be examined individually.

Instrument Phase - Aircraft and/or TS-2

In examining the training requirements for the instrument phase of training, two important facts surfaced about the choice of training media. First, the aircraft is limited in its ability to accomplish the training requirements. Second, the weight of effort devoted to instrument training is out of proportion to the training effectiveness that was derived. To substantiate these statements it is necessary to highlight certain aspects of the instrument training conducted in the current UPT program. First, the aircraft is limited in its ability to accomplish the training requirements mainly because of increased traffic control around approach facilities. The density of air traffic in the vicinity of UPT bases today necessitates the modification of practice instrument approaches to the extent that they are often unrealistic. Table XXIV shows the average practice approach minimums at the UPT bases. These values are very high compared to the typical minimums for these type approaches (TACAN and VOR to 600 feet, ILS to 200 feet, and GCA to 100 feet). Those facts do not show the use of outlying facilities which require a large amount of transit time and are becoming more difficult to use due to increased traffic. As it stands now, use of these facilities is possible only because of letters of agreement which limit the number of aircraft. With projected increases in traffic, use of these facilities will become more restricted. In addition to these high minimums, the practice approaches have other distortions. These distortions are as follows:

TABLE XXIV

UPT PRACTICE APPROACH MINIMUMS (AVERAGE)†

TACAN	VOR	ILS	GCA
MDA: 4600	MDA: 3050	DH: 300	DH: 860
† All altitudes in feet above ground level			

- The width of the azimuth and glide slope beams for practice precision approaches are wide at the heights and distances from the runway that are necessary to avoid other traffic. Gross deviations in rate of descent and heading at these distances show little deviation on the controller's radar scope.

- Approaches are often to a point in space rather than to an actual runway. Others are offset 1000 feet or more from the runway.

- Many of the VOR approaches are not to completion; i.e., they are flown only until radar contact is established.

- Instrument Landing System approaches at the home field are flown as much as 900 feet below the normal glide-path interception altitude. The resulting short final approach leaves little time for the student to get established on the glide path.

- No holding is authorized at some of the TACAN and VOR facilities.

It is important to realize that all the limitations brought out are not correctable so long as ATC must continue to use the aircraft as the instrument training device. While the deficiencies of the current system have been clearly established, it must be pointed out that the UPT system makes the best use possible of the airspace and facilities available. In addition to the distortions outlined above, the aircraft is further limited by design. The students in the T-38 trainer, for example, use the rear cockpit for instrument training and are unable to accomplish the important transition process from instruments to visual conditions realistically. Finally, because weather is favorable a good part of the time at some UPT bases, there is a high probability that many students complete UPT and never experience an instrument approach in weather with a breakout and transition to landing.

Second, the weight of effort devoted to instrument training using the aircraft is out of proportion to the training effectiveness derived. Table XXV shows a sampling of the number of approaches accomplished by the average student. The table also shows maximum and minimum numbers which reflect the range of training given to individual students. The number of approaches shown does not include those practiced in the T-4 and T-7 flight instrument trainers. While the flight instrument trainers are recognized for their procedural training value, approaches accomplished in these devices are not considered as equivalent to an actual approach. The T-4 and T-7 trainers have low quality control dynamics and no visual and motion cuing. Considering that approximately 22 percent of the flying in UPT is devoted to instrument training, then the numbers shown in Table XXV are extremely disappointing. Based on these findings, the TS-2 simulator was selected as the primary training device for accomplishing instrument training with the aircraft being used only for validation flights. As previously explained, the TS-2 has the capability to correct all of the problems brought out in this section. Table XXVI shows the capability of the simulator to increase the number of approaches accomplished in Future Undergraduate Pilot Training. As will be established in the evaluation section, this increase in quality can be achieved with a significant <u>decrease</u> in training cost.

TABLE XXV

INSTRUMENT APPROACH DATA

T-37 Classes 72-05, 72-06, 72-07, 72-08
T-38 Classes 72-01, 72-02, 72-03, 72-04
Columbus AFB

Type Approach	Actual Approaches Flown						Total Avg/Student
	T-37 Phase (195 students)			T-38 Phase (182 students)			
	Minimum	Avg/Student	Maximum	Minimum	Avg/Student	Maximum	
VOR	4	8.4	12				8.4
TACAN				3	7.8	14	7.8
CIRCLING				3	3.5	6	3.5
GCA	9	13.5	21	15	17.4	24	30.9
ILS				10	12.5	18	12.5

TABLE XXVI

INSTRUMENT APPROACH COMPARISONS

Event	Current UPT Aircraft	Future UPT		
		Aircraft	Simulator	Total
Precision Approach	43	20	75	95
Nonprecision Approach	16	8	40	48

Contact, Formation, and Navigation -- Aircraft and/or TS-3 Simulator

In examining the training requirements for the contact, formation, and navigation phase, three important facts were brought out about the choice of training media:

- The range of aircraft performance used for accomplishing contact and formation maneuvers definitely established a requirement for a more sophisticated simulator than the TS-2. The visual scene requirements for the navigation phase also exceeded the capability of the TS-2 simulator.

- The conceptual TS-3 simulator will be "limited" in its capability to produce sustained "g" cuing, and a full field-of-view visual scene. The use of "limited" to describe TS-3 capability recognizes the fact that all simulation involves compromise. After all, perfect simulation would not actually be simulation. In the case of the TS-3, the degree of compromise with the actual conditions is greater, for example, than the TS-2 because the range of conditions to be simulated is much broader. The limitations of the TS-3 will be based on a diminishing-returns design philosophy derived from the simulation research projects previously described. For example, the horizontal field of view for the visual scene may only be 140 degrees because the student pilot may only need that amount of view to achieve a high level of capability in the training maneuvers. Increasing the field of view may not increase the training value of the simulator or may only increase it a small amount with an attendant large increase in simulator cost. The capability of the TS-3 simulator used to determine the substitution values for replacing flying time were based on technology forecast and subjective training value estimates.

- The aircraft is not an efficient training device for introducing training maneuvers in the contact, formation and navigation phases. The complexity of maneuvers in these phases of training make it desirable to use a training device that can be set to initial maneuver conditions rapidly and the environmental conditions controlled to introduce the maneuvers at a low difficulty level.

For these reasons, the training time devoted to achieving initial capability in training maneuvers was allocated to the TS-3 simulator, while all reinforcement time for each maneuver was allocated to the aircraft. For those maneuvers where the simulator lacked the fidelity to train to initial capability, only a portion of the training time necessary for initial capability was allocated to the simulator and the remaining time was allocated to the aircraft.

This concludes the discussion on the main factors that influence the choice of training media for accomplishing the desired training task. It should be noted that throughout the process attention is given to the training requirements and matching the available training media with each requirement -- always employing the least costly device.

Curriculum

The purpose of this section is to show the results of applying the curriculum design methodology to the combination of training requirements, training concepts, and training equipment that make up the six remaining Future UPT system options.

Before presenting the details of the training time distribution, it should be pointed out that the training time is expressed in the traditional manner -- hours. Furthermore, simulation time and aircraft time are broken out to show the impact of simulation. However, it must be understood that an hour is only a standard of time; it is not a standard for determining training value. Ten hours of aircraft time does not equal ten hours of simulator time. Actually, direct comparison of an aircraft hour to a simulator hour is not possible without understanding the purpose of each hour of training. A simulator is not employed like an aircraft, and each device has unique capabilities. This fact should be kept in mind when examining the different system options.

The six system options are shown for review in Table XXVII. Each system option will be described separately.

TABLE XXVII

FUTURE UPT SYSTEM OPTIONS

Type System	Generalized					Specialized	
	20 Training Requirements		26 Training Requirements			30 Training Requirements	
System Name	Base-line	I-A	II-A	II-B	II-C	III-A	III-B
Aircraft	T-37/T-38	T-37/T-38	T-37/T-38	TA-2/T-38	TA-3	T-37/T-38/TA-4	TA-2/T-38/TA-4

Baseline

The Baseline system is today's UPT program. It is presented for comparative purposes. The Baseline case employs no simulators. Table XXVIII gives the amount of training time devoted to each phase.

TABLE XXVIII

CONCEPT I-A BASELINE

Primary	T-37	*T-4	Basic	T-38	*T-7
Contact	50.8		Contact	35.8	
Instruments	20.8	27.2	Instruments	22.9	30.7
Formation	3.9		Formation	35.1	
Navigation	7.0		Navigation	16.2	
Total	82.5		Total	110	

*Flight Instrument Trainer

Concept I-A ——

This system option is the Baseline system with simulation applied along with the new training improvements. This concept incorporates 20 training requirements. Table XXIX presents training time spent in the different phases using the aircraft and/or the simulators. The blocks are divided by year ranges which reflect the availability dates of the simulators.

Concepts II-A & B ——

These two system options are presented in Table XXX. They have the same number of hours and differ only in the type of primary training aircraft employed. Concepts II-A &B incorporate 26 training requirements.

TABLE XXIX

CONCEPT I-A

	1976 -- 1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
Primary	T-37 Hours	TS-2 Hours	T-37 Hours	TS-2 Hours	TS-3 Hours
Contact	50.8		34.8		16.0
Instruments	2.8	31.4	2.8	31.4	
Formation	3.9		2.9		1.0
Navigation	7.0		5.1		1.9
Total	64.5	31.4	45.6	31.4	18.9
	1976 -- 1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
Basic	T-38 Hours	TS-2 Hours	T-38 Hours	TS-2 Hours	TS-3 Hours
Contact	34.6		20.4		14.2
Instruments	2.6	36.4	2.6	36.4	
Formation	36.4		22.8		13.6
Navigation	16.2		14.3		1.9
Total	89.8	36.4	60.1	36.4	29.7

TABLE XXX

CONCEPT II-A & -B

Primary	1976 -- 1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
	T-37 or TA-2 Hours	TS-2 Hours	T-37 or TA-2 Hours	TS-2 Hours	TS-3 Hours
Contact	50.8		34.8		16.0
Instruments	2.8	35.3	2.8	35.3	
Formation	16.9		11.5		5.4
Navigation	9.8		7.9		1.9
Total	80.3	35.3	57.0	35.3	23.3

Basic	1976-1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
	T-38 Hours	TS-2 Hours	T-38 Hours	TS-2 Hours	TS-3 Hours
Contact	34.8		20.5		14.3
Instruments	2.6	36.4	2.6	36.4	
Formation	27.6		17.3		10.3
Navigation	26.5		24.6		1.9
Total	91.5	36.4	65.0	36.4	26.5

Concept II-G ———

This system option is a one aircraft program. Table XXXI shows that the time period of this system does not begin until the early 1980s and as a result employs both simulators from its beginning. The system cannot be employed earlier because of the life remaining in our current trainers. Concept II-G incorporates 26 training requirements.

Concept III-A and -B ———

These two system options are presented in Table XXXII. The systems have the same number of hours and differ only in the type of primary training aircraft employed. The acronym FAIR stands for Fighter, Attack, Interceptor, and Reconnaissance, while the TTB acronym represents Tanker, Transport, and Bomber specialization. These two systems incorporate 30 training requirements.

Summary ———

Tables XXXIII and XXXIV provide total hour summaries on the Baseline and the six system options. In addition, they show the number of dynamic observer hours (student flyings as third seat observer or team flight), copilot time, the number of cockpit procedures trainer hours, and academic hours.

TABLE XXXI

CONCEPT II-G

	1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
	TA-3 Hours	TS-2 Hours	TS-3 Hours
Contact	53.8		24.0
Instruments	4.5	76.1	
Formation	26.5		16.0
Navigation	22.3		7.0
Total	107.1	76.1	47.0

TABLE XXXII

CONCEPT III-A & -B

	1976 -- 1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 & TS-3 Simulator		
Primary	T-37 or TA-2 Hours	TS-2 Hours	T-37 or TA-2 Hours	TS-2 Hours	TS-3 Hours
Contact	50.8		34.8		16.0
Instruments	2.8	35.3	2.8	35.3	
Formation	16.9		11.5		5.4
Navigation	9.8		7.9		1.9
Total	80.3	35.3	57.0	35.3	23.3

	1976-1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulator		
Specialized FAIR	T-38 Hours	TS-2 Hours	T-38 Hours	TS-2 Hours	TS-3 Hours
Contact	34.8		20.5		14.3
Instruments	2.6	36.4	2.6	36.4	
Formation	27.6		17.3		10.3
Navigation	26.5		24.6		1.9
Specialized	13.2		9.0		4.2
Total	104.7	36.4	74.0	36.4	30.7

TABLE XXXII (Continued)

Specialized [illegible]	1976 -- 1983 Aircraft and TS-2 Simulator		1983 -- 1990 Aircraft, TS-2 and TS-3 Simulators		
	TA-4 Hours	TS-2 Hours	TA-4 Hours	TS-2 Hours	TS-3 Hours
Contact	39.5		25.3		14.2
Instruments	3.0	36.4	3.0	36.4	
Formation	8.0		4.0		4.0
Navigation	33.0		31.5		1.5
Total	83.5	36.4	63.8	36.4	19.7

System Equipment Requirements

The quantities of aircraft, simulators, cockpit procedures trainers and bases required for each system option are summarized in Tables XXXV and XXXVI.

The Baseline system employs only the T-4 and T-7 instrument trainers instead of TS-2 and TS-3 simulators.

Quantities of T-37 and T-38 aircraft and their associated cockpit mockups and CPTs reflect the maximum numbers required during the system life cycle. The quantities in parentheses are the same quantity plus attrition aircraft through year 1990. As simulation is introduced the T-37 and T-38 requirements will decline.

Conceptual aircraft quantities not in parentheses are required for system operation for the 3665 graduate production level at that point in time when the system is fully operational. Numbers in parentheses include attrition aircraft through year 1990.

The number of CPTs shown for system II-G reflect the requirements until year 1986. When the TA-3 aircraft is introduced the quantity of mockups and CPTs will decline. The number of bases shown in the tables were derived from a base capacity analysis which will be described.

TABLE XXXIII
CURRICULUM SUMMARY
(Systems Employing TS-2 Simulators)

Aircraft / Phase	Gen -- 20 TR				Gen -- 26 TR					Spec -- 30 TR					
	baseline		I-A		II-A		II-B		II-G	III-A			III-B		
Aircraft	T-37	T-38	T-37	T-38	T-37	T-38	TA-2	T-38	TA-3	T-37	T-38	TA-4	TA-2	T-38	TA-4
Phase	Pri	Basic	Pri	Basic	Pri	Basic	Pri	Basic	Single Phase	Pri	Basic FAIR	Basic TTB	Pri	Basic FAIR	Basic TTB
Hands-On Flying Time	82.5	110	64.5	89.8	80.3	91.5	80.3	91.5	154.1	80.3	104.7	83.5	80.3	104.7	83.5
Dynamic Observer Time	--	--	5.2	12.4	5.2	12.4	5.2	12.4	24.2	5.2	12.4	67.5	5.2	12.4	67.5
Copilot Time	--	--	--	--	--	--	--	--	--	--	--	16.0	--	--	16.0
TS-2 Simulator	†27.2	†30.7	31.4	36.4	35.3	36.4	35.3	36.4	76.1	35.3	36.4	36.4	35.3	36.4	36.4
Mockup Hours	N/A	N/A	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CPT-1 Hours	N/A	N/A	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CPT-2 Hours	N/A	N/A	12.0	15.0	14.0	16.0	14.0	16.0	27.0	14.0	17.0	15.0	14.0	17.0	15.0
Academic Hours	196.0	62.0	178.0	88.0	178.0	112.0	178.0	112.0	231.0	178.0	117.0	114.0	178.0	117.0	114.0

† T-4 and T-7 Flight Instrument Trainer Hours

TABLE XXXIV

CURRICULUM SUMMARY

(Systems Employing TS-2/TS-3 Simulators)

Aircraft / Phase	Gen -- 20 TR Baseline T-37 Pri	Gen -- 20 TR Baseline T-38 Basic	Gen -- 20 TR I-A T-37 Pri	Gen -- 20 TR I-A T-38 Basic	Gen -- 26 TR II-A T-37 Pri	Gen -- 26 TR II-A T-38 Basic	Gen -- 26 TR II-B TA-2 Pri	Gen -- 26 TR II-B T-38 Basic	Gen -- 26 TR II-C TA-3 Single Phase	Spec -- 30 TR III-A T-37 Pri	Spec -- 30 TR III-A T-38 Basic FAIR	Spec -- 30 TR III-A TA-4 Basic TTB	Spec -- 30 TR III-B TA-2 Pri	Spec -- 30 TR III-B T-38 Basic FAIR	Spec -- 30 TR III-B TA-4 Basic TTB
Hands-On Flying Time	82.5	110.0	45.6	60.1	57.0	65.0	57.0	65.0	[illegible]	57.0	74.0	63.8	57.0	74.0	63.8
Dynamic Observer Time	--	--	3.9	8.0	3.9	8.0	3.9	8.0	21.8	3.9	8.0	49.8	3.9	8.0	49.8
Copilot Time	--	--	--	--	--	--	--		--	--	--	14.0	--	--	14.0
TS-2 Simulator, Hrs	27.2†	†30.7	31.4	36.4	35.3	36.4	35.3	[illegible]	[illegible]	35.3	36.4	36.4	35.3	36.4	36.4
TS-3 Simulator, Hrs	--	--	18.9	29.7	23.3	26.5	23.3	[illegible]	47.0	23.3	30.7	19.7	23.3	30.7	19.7
Mockup Hours	N/A	N/A	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CPT-1 Hours	N/A	N/A	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
CPT-2 Hours	N/A	N/A	12.0	15.0	14.0	16.0	14.0	16.0	27.0	14.0	17.0	15.0	14.0	17.0	15.0
Academic Hours	196.0	82.0	178.0	88.0	178.0	112.0	178.0	112.0	[illegible]	178.0	117.0	114.0	178.0	117.0	114.0

† T-4 and T-7 Flight Instrument Trainer Hours

TABLE XXXV

EQUIPMENT SUMMARY
(Systems Employing the TS-2 Simulator)
3665 Graduate Production

Type System / System Name	Gen -- 20 TR			Gen -- 26 TR						Spec -- 30 TR					
	Baseline	I-A		II-A		II-B		II-G		III-A			III-B		
Aircraft															
T-37	630 (703)	528 (593)		657 (728)						657 (728)					
T-38	819 (1041)	720 (901)		675 (864)		675 (865)				675 (811)			675 (811)		
TA-2						504 (519)							504 (519)		
TA-3								1020 (1079)							
TA-4										175 (199)			175 (199)		
Simulators	(T-4): 73														
TS-2	(T-7): 89	96		112		112		112		112			112		
Procedure Trainer		Pri	Basic	Pri	Basic	Pri	Basic	Pri	Basic	Pri	FAIR	TTB	Pri	FAIR	TTB
Mockup	-0-	42	42	42	42	42	42	42	42	42	21	28	42	21	28
CPT-1	-0-	24	24	21	21	21	21	21	24	21	14	14	21	14	14
CPT-2	-0-	18	18	21	21	21	21	21	36	21	14	14	21	14	14
Number Bases	8	6		7		7		6		7			7		

÷Aircraft quantities are those required for system operation.
The numbers in parentheses include attrition aircraft for the 1972-1990 period.

TABLE XXXVI

EQUIPMENT SUMMARY
(Systems Employing the TS-2/TS-3 Simulator)
3565 Graduate Production

Type System	Gen -- 20 TR	Gen -- 20 TR		Gen -- 25 TR						Spec -- 30 TR					
System Name	Baseline	I-A		II-A		II-B		II-C		III-A			III-B		
Aircraft*															
T-37	630 (733)	[illegible]28 (580)		657 (721)						657 (721)					
T-38	819 (1041)	[illegible] (588)		675 (845)		675 (845)				575 (802)			675 (802)		
TA-2						357 (364)							357 (364)		
TA-3								708 (734)							
TA-4										175 (195)			175 (195)		
Simulators															
TS-2	(T-4): 73	96		112		112		112		112			112		
TS-3	(T-7): 89	[illegible]		112		112		112		112			112		
Procedure Trainer		Pri	Basic	Pri	Basic	Pri	Basic	Pri	Basic	Pri	FAIR	TTB	Pri	FAIR	TTB
Mockup	-0-	42	42	42	42	42	42	42	42	42	21	28	42	21	28
CPT-1	-0-	24	24	21	21	21	21	21	28	21	14	14	21	14	14
CPT-2	-0-	15	18	21	21	21	21	21	36	21	14	14	21	14	14
Number of Bases	8	6		7		7		6		7			7		

*Aircraft Quantities are those required for system operation.
The numbers in parentheses include attrition aircraft for the 1972-1990 period.

Base Capacity Analysis

The ATC "Maximum Base Capability Study" was used as the computation model to determine the maximum operational capability of Future UPT bases and the minimum number of such bases required for the various system options. The "Maximum Base Capability Study" computes the present maximum annual pilot production capability of each UPT base in terms of operational potential (runway capabilities). It uses specific base-related statistics to arrive at these production capabilities.

It was beyond the scope of this analysis to determine which, or how many, of the present UPT bases will actually be used in Future Undergraduate Pilot Training. For this reason, statistics for an "average" UPT base were used in this analysis. Results are given in terms of the minimum number of "average" bases required to meet the Future UPT total production goals.

One key assumption was made to make this "averaging" a meaningful exercise; namely, that facilities at the UPT bases are sufficient or will be made sufficient to meet the training load specified for the various system options.

Identification of increased facilities requirements was accomplished for those system options requiring more facilities and this information is included in the system costing.

The computation of a maximum operational capability per year of a UPT base involves several steps. It begins with the number of sorties capable of being launched per hour (sortie launch rate) and applies such factors as required number of overhead sorties, operations/maintenance success factor, weather considerations, daylight hours available per day, working days available per year, number of sorties required to support a specified course of instruction, length of the course of instruction, and attrition rate of the students in the course. The result is the maximum operational potential (expressed in the number of graduates) a base is capable of producing per year.

It is important to bring out that no allowance is made in these computations for operational factors which may limit the attainment of maximum capability operation. These factors include such items as extended nonflyable weather above that predicted, major runway repairs, and air traffic control inefficiencies. For these reasons, the decision was made not to load any base over 95 percent of computed capacity.

Finally, a decision was made for the analysis to maintain the number of bases required for the first level of simulation (TS-2) after the second level of simulation (TS-3) is introduced. This decision was made for three reasons:

1) The Airspace and Air Traffic Control Analysis indicates increasing pressure on UPT flying activities in the post-1980 time frame. Undergraduate Pilot Training bases may not have the airspace available to support a production level based solely on the maximum number of sorties possible per day. The increase in civil air traffic will, most likely, make it mandatory that UPT flying activity be distributed over a wide area with less activity at any given location.

2) It was felt that the large student loads required if only four or five bases were used would create scheduling and student management difficulties in the flying training program.

3) The TS-2 simulators, buildings, additional training facilities, and housing will already be in place at the number of bases required under the TS-2

level of simulation. Closing bases and increasing the student load at the remaining bases would require moving of this equipment and the construction of additional buildings.

With these two decisions applied to the Maximum Base Capability Model, the number of bases was computed and the resulting required production per base used to compute student loads. The conclusions drawn from this analysis are as follows:

- The 20 training requirements, jet, generalized multiphase training system (T-37/T-38) will require a minimum of six bases. A total expenditure of approximately $6,534,000 for additional bachelor officer housing will be required if six bases are used.

- The 26 training requirement, jet, generalized multiphase training systems (T-37 and T-38 or TA-2 and T-38) and the 30 training requirement, jet, specialized multiphase training systems (T-37, T-38, and TA-4 or TA-2, T-38 and TA-4) will require a minimum of seven bases. A total expenditure of approximately $5,621,000 for additional bachelor officer housing will be required if seven bases are used. Adoption of a 30 training requirement option will require one additional runway at the seventh base at a cost of approximately three million dollars.

- The 26 training requirement, jet, generalized single phase training system (TA-3) will require a minimum of six bases. A total expenditure of approximately $6,270,000 for additional bachelor officer housing will be required if six bases are used.

Additional Facilities Required

Additional facility requirements for the system options are listed in Tables XXXVII (with TS-2 simulators) and XXXVIII (with TS-2 and TS-3 simulators). The major requirements are for simulator facilities and additional BOQ units. As previously explained, one additional runway is required for specialized systems since seven, three-runway bases are required.

TABLE XXXVII

ADDITIONAL FACILITIES REQUIRED
Systems Employing TS-2 Simulator

System	Generalized					Specialized	
	20 Training Requirements		26 Training Requirements			30 Training Requirements	
	Baseline	I-A	II-A	II-B	II-C	III-A	III-B
Aircraft	T-37 T-38	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Simulator Facilities† (Sq Ft)	-0-	321,240	374,780	374,780	374,780	374,780	374,780
BOQ Facilities ‡ (Units)	-0-	594	511	511	570	511	511
Additional Runways ‡	-0-	-0-	-0-	-0-	-0-	-0-	1

†$40 per square foot.
‡$11,000 per unit (1 person) IAW AF Pamphlet 88-16, 28 May 70, "Military Construction Pricing Guide."
‡$3.0 Million per Runway.

TABLE XXXVIII

ADDITIONAL FACILITIES REQUIRED
(Systems Employing TS-2/TS-3 Simulators)

System	Generalized					Specialized	
	20 Training Requirements		26 Training Requirements			30 Training Requirements	
	Baseline	I-A	II-A	II-B	II-G	III-A	III-B
Aircraft	T-37 T-38	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
†Simulator Facilities (Sq Ft)	-0-	562,170	749,560	749,560	749,560	749,560	749,560
‡BOQ Facilities (Units)	-0-	594	511	511	570	511	511
ǂAdditional Runways	-0-	-0-	-0-	-0-	-0-	1	1

† $40 per square foot
‡ $11,000 per unit (1 person) IAW AF Pamphlet 88-16, 28 May 70, "Military Construction Pricing Guide."
ǂ $3.0 million per runway.

Total System Personnel Requirements

The permanent party personnel requirements for each system option are listed in Tables XXXIX (with TS-2 simulators) and XL (with TS-2 and TS-3 simulators.) These requirements are output data from the UPT systems model. In addition, the student population is presented in Table XLI. The data represent the student load per base. System student population was found by multiplying student load per base by the number of bases in the system. The student population is based on 3665 graduates per year. Systems with longer course lengths have higher student loads relative to those systems with shorter course lengths.

TABLE XXXIX

PERMANENT PARTY PERSONNEL
(Systems Employing TS-2 Simulator)

Type System	Gen -- 20 TR		Gen -- 26 TR			Spec -- 30 TR	
System Name	Baseline	I-A	II-A	II-B	II-G	III-A	III-B
Aircraft	T-37 T-38	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Officers	3,288	3,276	3,647	3,654	3,198	3,661	3,675
Airmen	11,592	9,324	10,374	10,626	9,606	10,143	10,388
Civilian	5,320	4,332	4,872	4,956	4,428	4,788	4,879
Total	20,200	16,932	18,866	19,236	17,232	18,592	18,942

TABLE XL

PERMANENT PARTY PERSONNEL
(Systems Employing TS-2/TS-3 Simulators)

Type System	Gen -- 20 TR		Gen -- 26 TR			Spec -- 30 TR	
System Name	Baseline	I-A	II-A	II-B	II-G	III-A	III-B
Aircraft	T-37 T-38	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Officers	3,288	3,228	3,605	3,612	3,156	3,640	3,647
Airmen	11,592	7,794	8,904	9,086	8,064	8,862	9,037
Civilian	5,320	3,798	4,354	4,403	3,876	4,347	4,389
Total	20,200	14,820	16,863	17,101	15,096	16,849	17,073

TABLE XLI

STUDENT PERSONNEL SUMMARY
(Systems Employing Either TS-2 or TS-2/TS-3 Simulators)

Type System	Gen -- 20 TR	Gen -- 26 TR			Spec -- 30 TR	
System Name	I-A	II-A	II-B	II-G	II-A	III-B
Aircraft	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Student Load per Base	564	539 (511)†	539 (511)†	544	534	534
Number of Bases	6	6 (3 Rwy) 1 (2 Rwy) 7 Total	6 (3 Rwy) 1 (1 Rwy) 7 Total	6	7	7
Total System Student Population	3,384	3,745	3,745	3,264	3,738	3,738

† Numbers in parentheses are student load for 2 Runway Base.

MISSION ANALYSIS FINDINGS (Appendix I and J)

The purpose of this final section is to show the major decision dates and cost of each of the six future system options described in the previous section. Figure 32 is a portrayal of these six system options. The figure serves as a decision tree and maps out the logical paths available to the Air Force for conducting UPT in the 1972 through 1990 time period.

Decision Tree Design

It is important to highlight the fact that the decision tree design places emphasis on training requirements and concepts. One of the significant findings of the Mission Analysis establishes that Future UPT should include increased training requirements, and, therefore, the path toward increased training requirements is the most logical one. All of the data that will be presented on the six system options are based on a total pilot production of 3665 students annually through 1990. Therefore, if graduate production for example should decrease, some of the decision dates for the various system options would change. The simulator decision dates would not change, but the aircraft decision dates would change to later dates.

System Options Evaluation

Each of the six system options will now be evaluated in terms of the major decision dates necessary to reach full implementation. Certain advantages and disadvantages are given for each system option.

Option I-A, T-37/T-38

Only one system option is viable if the Air Force continues with today's 20 training requirements. No other mix of aircraft were considered because with simulation applied to today's 192.5 jet hour program -- the T-37 and T-38 will last until 1990. Also, no consideration was given to a specialized training approach because with only 20 training requirements there is no justification based on the commonality of training requirements to adopt a specialized approach. You will note on the decision tree how the insufficiency dates for the T-37 and T-38 aircraft change as simulation is introduced.

The decision dates for the two simulators will be explained in detail. Table XLII shows the program phase for the TS-2 simulator. It should be noted that because TS-2 is off-the-shelf technology, there is no need to go through the validation, ratification, and full scale development phase. The only reason a program decision is necessary in 1973 is to ensure that the simulator buildings are initiated in the MCP cycle, to be ready in 1976 when the TS-2s are delivered. This program phasing for TS-2 will be the same for all system options. Therefore, it will not be covered in detail again.

Table XLIII shows the program phase for the TS-3 simulator. It should be remembered that the program decision date of 1977 depends on validation by the advanced simulation research underway in UPT and simulation research programmed for other Air Force projects. The program phasing for TS-3 is also the same for all system options and will not be covered in detail again.

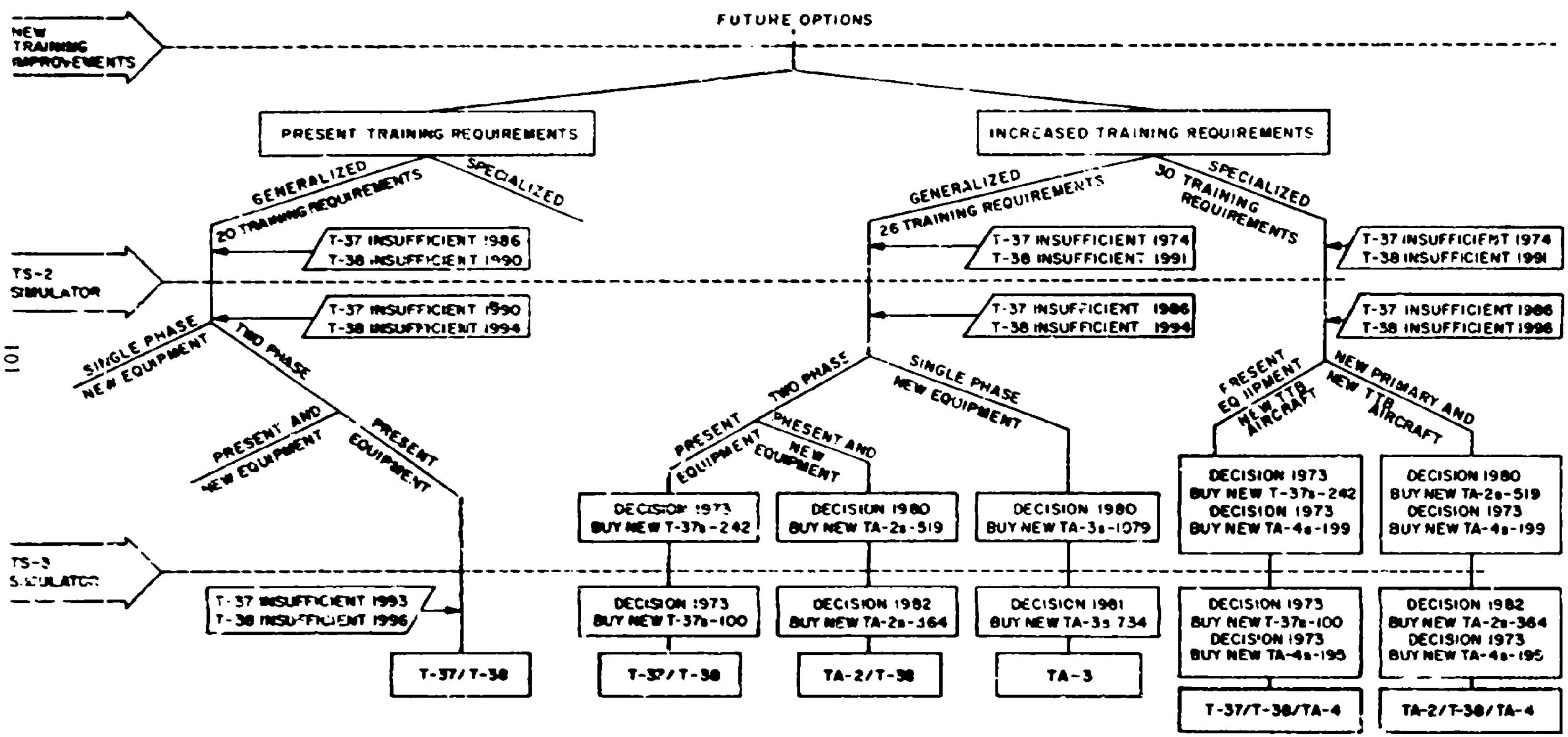


Figure 32. Decision Tree

TABLE XLII

TS-2 PROGRAM PHASE

Phase	Date
• Program Decision	1973
Validation Phase	
Ratification Decision	
Full Scale Development Phase	
a. Development Award	
b. Completion of First Unit	
c. Test	
• Production Decision	1974
Production Phase	
a. Award	1974
b. Delivery of First Unit	1976
c. Delivery Schedule, Maximum complexes/cockpits	12/48 per year

TABLE XLIII

TS-3 PROGRAM PHASE

Phase	Date
• Program Decision	1977
Validation Phase	1977
Ratification Decision	1977
Full Scale Development Phase	1977-1980
a. Development Award	1978
b. Completion of First Unit	1980
c. Test	1980
• Production Decision	1980
Production Phase	
a. Award	1981
b. Delivery of First Unit	1983
c. Delivery Schedule, Maximum complexes/cockpits	12/48 per year

In summary of this system option, it incorporates today's level of training with the benefits of simulation applied. The findings of the Mission Analysis show that while this system option may be adequate by today's standard it is not adequate for the 1972-1990 time period.

The remaining five options provide for increased training requirements, and are designed to provide the quality needed for the Future Undergraduate Pilot Training. The next three system options to be discussed incorporate 26 training requirements.

Option II-A, T-37/T-38

The decision tree (Figure 32) shows the insufficiency dates of the T-37 and T-38 aircraft for this option. The system uses the T-37 and T-38 in equal proportions of flying and simulator hours. As a result, the T-37 is driven to insufficiency in numbers prior to use of the TS-2 simulator. However, the insufficiency is small, approximately 11 aircraft, and can be overcome by temporarily going to a higher than normal utilization rate. The major disadvantage of this system concerns the necessary decision to buy new T-37 aircraft in 1973.

Although buying T-37 aircraft is an acceptable solution to make the system last through 1990 -- it is not a timely one. The decision on the number of T-37 aircraft to buy depends on the confidence level of TS-3 simulation. If enough T-37s are bought to cover a major slippage in TS-3 simulation (Table XLIII) -- 242 aircraft must be purchased in 1973 for delivery beginning 1975. If T-37s are purchased based on TS-3 developing as forecast, then only 100 aircraft must be purchased in 1973 for delivery beginning 1975.

Option II-B, TA-2/T-38

This system option (reference Figure 32) is the same as Option II-A except in this option, new T-37 aircraft are not purchased. Instead, the T-37 is allowed to reach retirement and a new primary jet trainer is purchased. The simulation decision dates remain the same as previously explained. The T-37 insufficiency date of 1974 is corrected in the same manner as previously explained for Option II-A. The T-37 insufficiency date of 1986 cannot be extended because at this point large numbers of aircraft reach retirement.

The program phase of the new primary trainer is shown in Table XLIV. The program decision date of 1982 is based on the TS-3 simulator forecast. In this case, a total of 364 aircraft are purchased. If the TS-3 simulator does not develop as forecast, the decision date for the TA-2 aircraft must be moved forward to 1980. The decision date has to be moved up to allow for the increased number of aircraft that have to be produced -- 519 (total).

The major advantage of this system over the T-37/T-38 alternative (Option II-A) is the extended decision time. The major decision date for the TA-2 aircraft comes after the forecast decision date of the TS-3 simulator. Therefore, the decision on how many aircraft to purchase can be made with much more visibility. In addition, the TA-2 aircraft will provide the advantages of a more modern aircraft that meets all the future requirements for a primary trainer.

Option II-C, TA-3

This option (reference Figure 32) is a unique one. It uses a single phase generalized approach to accomplish the 26 training requirements, with the conceptual aircraft, the TA-3. The system starts out the same as previously explained in Option II-A for 26 training requirements. This is necessary to comply with the requirement that the current trainer aircraft life be used before new equipment is purchased. The only decision dates for this option that has not been explained previously concern the decision date for the TA-3 aircraft.

TABLE XLIV

TA-2 PROGRAM PHASE

Phase	Date
• Program Decision	1982
Validation Phase	1982
Ratification Decision	1982
Full Scale Development Phase	1982-1986
a. Development Award	1983
b. Completion of First Unit	1985
c. Test	1985-1986
• Production Decision	1985
Production Phase	
a. Award	1986
b. Delivery of First Unit	1987
c. Delivery Schedule, Maximum	300-360 per year

TABLE XLV

TA-3 PROGRAM PHASE

Phase	Date
• Program Decision	1981
Validation Phase	1981
Ratification Decision	1981
Full Scale Development Phase	1981-1985
a. Development Award	1982
b. Completion of First Unit	1984
c. Test	1984-1985
• Production Decision	1984
Production Phase	
a. Award	1985
b. Delivery of First Unit	1986
c. Delivery Schedule, Maximum	300-360 per year

The program phase for the TA-3 purchase is as outlined in Table XLV. The program decision date of 1981 is based on the TS-3 forecast availability and the purchase of 734 aircraft. If the TS-3 simulator does not develop as forecast, the decision date must be moved forward to 1980 to allow for the increased number of aircraft that have to be produced -- 1079 total.

The major advantage of this system design is its simplicity. Using a single aircraft for the entire training program provides for a wide range of flexibility in the training approach. One specific advantage is the reduction in flying hours because the transition of students to a different aircraft midway in the course is not required. As a result, the course calls for 14 fewer hours. Another advantage of this concept is the fewer number of bases required to operate the program. The major disadvantage of this approach is the heavy systems investment outlay required to procure the TA-3.

The final two system options to be discussed incorporate 30 training requirements (specialized training).

Option III-A, T-37/T-38/TA-4

The major decision dates for this system option are shown on the decision tree (Figure 32). The dates have all been previously explained except the decision on the TA-4 aircraft. The decision dates necessary for extending the T-37 life are the same as Option II-A because the primary phase of training is the same in both II-A and III-A.

The program phase for the TA-4 with the major decision dates is as shown in Table XLVI. It is important to point out that the Mission Analysis considered only conceptual aircraft designs for purposes of comparison. All of the dates shown on this table assume the design of a new aircraft to meet the specifications. However, there are several off-the-shelf light jet transport aircraft that might meet the specifications and, thereby, reduce this time schedule. If the decision were made to go to a 30 training requirements specialized Future UPT, it would be to the Air Force's advantage to further pursue this possibility.

TABLE XLVI

TA-4 PROGRAM PHASE

Phase	Date
● Program Decision	1973
Validation Phase	1973
Ratification Decision	1973
Full Scale Development Phase	1973-1977
a. Development Award	1974
b. Completion of First Unit	1976
c. Test	1976-1977
● Production Decision	1976
Production Phase	
a. Award	1977
b. Delivery of First Unit	1978
c. Delivery Schedule, Maximum	144 per year

The major advantage of the specialized 30 training requirements concept is its ability to provide more tailored training for the new pilots initial assignment. The disadvantages center around system flexibility (ability to respond to changes in graduate assignment distribution) and complexity of operation (three aircraft operating on the same base). These disadvantages were considered in the Mission Analysis and allowances were made to ensure an adequate level of flexibility and an acceptable level of operational complexity.

Option III-B, TA-2/T-38/TA-4

The major decision dates for this option are shown on the Decision Tree (Figure 32). All of the details for these decisions have already been explained under the other system options.

The major advantage of this option over the previous specialized Option III-A concerns the type primary aircraft and the critical nature of the decision date. The 1982 decision date on the TA-2 allows better visibility on the TS-3 simulator development and provides for a more modern primary trainer that completely meets all of the future primary trainer requirements.

System Option Costing

Detailed costing was accomplished on each of the six future system options. The costing was done primarily for the purpose of comparing the different systems. Specifically, the costing information was needed to answer questions about the total cost of a given system, how much savings could be realized by employing simulation, how much would the increased training requirements cost, and what the cost would be to introduce the new conceptual aircraft. Each of these questions will be answered in detail. However, before proceeding it is necessary to define certain costing terminology that is critical to the understanding of the costing results.

- Total System Outlay -- This category is the total outlay in terms of 1971 dollars including DDT&E, investment, and operations.
- Terminal Value -- Terminal value refers to the value of equipment life remaining at the end of year 1990. Because equipment purchases occur at various times throughout the 19-year period of the study, terminal value is used to place systems with different life spans on an equitable cost basis for comparison. This is accomplished by deducting the value of the remaining equipment at the end of the 19-year period from the equipment investment.
- Period Cost -- This value is derived by subtracting terminal value from the total system outlay. In this manner, systems with different life spans can be compared on an equitable cost basis.
- Cost Savings Over the Baseline -- The period cost of the system options are compared with the period cost of the baseline system. Cost savings are shown as positive numbers. Numbers in parentheses indicate a period cost greater than the Baseline.
- Present Value -- The present value concept recognizes the time-value of money. Yearly cash flows are discounted at a 10 percent rate and summed for the 19-year period. Terminal Value (discounted through 1990) is subtracted from the sum to arrive at the present value.

System Cost Data

Each of the six future system options and the baseline system (today's UPT program) were costed for operation through 1990. The total cost of each system was determined by summing the Design, Development Testing, and Evaluation (DDT&E) cost, investment cost, and operating cost for each year of operation. The costing factors were properly sequenced

to reflect the transition dates and equipment purchase dates previously described for each system. The result of this effort produced cash flow profiles for each of the systems. Figure 33 is a cash flow profile of the baseline system. It shows that in order to make today's program last through 1990, years 1973 through 1976 will require a large investment to buy additional aircraft and new aircraft avionics necessary for future operations. The operating cost settles down after 1974 to between 345 to 347 million dollars annually. If all the DDT&E, investment and operating cost are summed up for the 19-year period, a total system outlay figure results (in this baseline case it adds up to 6.786 billion dollars). Figure 33 also shows that immediately after 1990 the system has a terminal value of 164 million. This terminal value figure is subtracted from the total system outlay to give the period cost (19-year period) for operating the pilot training system.

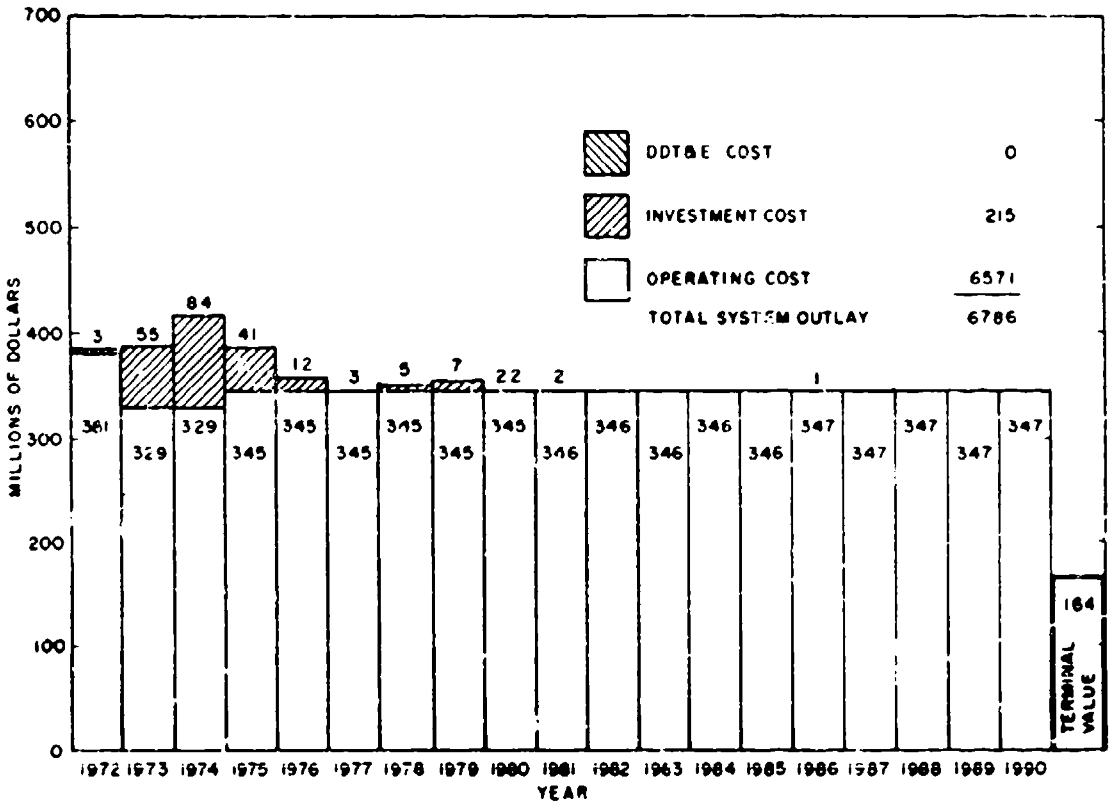


Figure 33. System Cash Flow

Cash flow profiles for the six viable system options were accomplished with only TS-2 simulation applied through 1990. Another set of cash flow profiles was accomplished with TS-2 and TS-3 simulation applied through 1990. It should be remembered that TS-2 simulation cannot be in operation before 1976 and TS-3 before 1983.

The results of these cash flow computations are shown in Table XLVII for TS-2 only and Table XLVIII for TS-2 and TS-3. These two tables will provide the basis for the cost analysis of the six future system options. The tables will be referred to frequently for comparing the different systems.

TABLE XLVII

SYSTEM COST DATA, TS-2

	Gen -- 20 TR		Gen -- 26 TR			Spec -- 30 TR	
	Baseline T-37 T-38*	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Total System Outlay	6,786	6,244	6,810	7,102	7,966	7,078	7,370
Terminal Value	(164)	(174)	(213)	(352)	(799)	(456)	(595)
Period Cost	6,622	6,070	6,597	6,750	7,167	6,622	6,775
Cost Savings Over Baseline	--	552	25	(128)	(545)	0	(153)
Present Value	3,175	2,970	3,210	3,235	3,412	3,341	3,366

*No TS-2 for Baseline

TABLE XLVIII

SYSTEM COST DATA, TS-2/TS-3

	Gen -- 20 TR		Gen -- 26 TR			Spec -- 30 TR	
	Baseline T-37 T-38*	T-37 T-38	T-37 T-38	TA-2 T-38	TA-3	T-37 T-38 TA-4	TA-2 T-38 TA-4
Total System Outlay	6,786	6,079	6,391	6,991	7,681	7,012	7,287
Terminal Value	(164)	(279)	(307)	(454)	(758	(543)	(690)
Period Cost	6,622	5,800	6,409	6,537	6,923	6,469	6,597
Cost Savings Over Baseline	--	822	213	85	(301)	153	25
Present Value	3,175	2,920	3,174	3,198	3,315	3,313	3,337

*No TS-2/TS-3 For Baseline

System Cost Ranking

One of the key questions in the analysis of the six system options concerns their ranking in terms of the period cost. Based on the figures compiled in Table XLVIII the cost ranking is as follows (both TS-2 and TS-3 applied);

- T-37/T-38 20 Training Requirements (least expensive)
- T-37/T-38 26 Training Requirements
- T-37/T-38/TA-4 30 Training Requirements
- TA-2/T-38 26 Training Requirements
- TA-2/T-38/TA-4 30 Training Requirements
- Baseline (no simulation)
- TA-3 26 Training Requirements (most expensive)

This ranking based on period cost shows that there are five viable system options that are less expensive than the present method of training, and four of these systems represent increased quality based on expanded training requirements. While period costs represent the amount of dollars expended (after terminal value adjustment), the more meaningful cost for determining the system rankings is the present value cost.

The present value concept adjusts the future expenditures made in the different years to today's value (recognizing the time value of money) and puts all systems on an equitable basis for comparison. Using the present value figures from Table XLVII and XLVIII cost rankings were established for the different systems. Table XLIX shows these rankings (number one being least expensive). The first ranking (column 1) is within training requirements and holds true for either of the simulator (TS-2 or TS-2/TS-3) combinations. For example, for 20 training requirements, the two systems indicated, always rank one and two. Likewise for 26 training requirements, the three systems shown always rank one, two, and three. In other words, the cost ranking within training requirement categories does not change with simulator level. However, across training requirement categories, a change in cost ranking does occur between the baseline and generalized 26 training requirements option using the T-37 and T-38. A change also occurs between the single phase TA-3 option and the specialized option using the TA-2/T-38/TA-4. Based on present value ranking and with TS-2 only, there is only one system that is less expensive than the baseline. However, the systems ranking third and fourth are only slightly more expensive (see Tables XLVII) and they incorporate 26 training requirements. With TS-2 and TS-3 applied, two systems are less expensive than the baseline (see Table XLVII).

TABLE XLIX

COST RANKING
(Using Present Value of Period Cost)

System	Either Simulator TS-2/TS-3	TS-2	TS-2 TS-3
20 Training Requirements			
Gen T-37/T-38 with simulation	1	1	1
Baseline (no simulation)	2	2	3
26 Training Requirements			
Gen T-37/T-38 with simulation	1	3	2
Gen TA-2/T-38 with simulation	2	4	4
Gen TA-3 with simulation	3	7	6
30 Training Requirements			
Spec T-37/T-38/TA-4 with simulation	1	5	5
Spec TA-2/T-38/TA-4 with simulation	2	6	7

Cost of Increased Training Requirements

It is significant to the cost ranking analysis to understand the impact of going from 20 training requirements to 26 or thirty. In order to determine this type of cost, it will be necessary to select from the six system options three systems with the most commonality that differ only in the number of training requirements they incorporate. The three options selected are Concept I-A, II-A, and III-A. All three systems use the T-37 and T-38 aircraft. Concept III-A employs an additional aircraft because it is a specialized program.

Tables L and LI show both the cost and training differences, respectively, among these three alternative systems using TS-2 and TS-3 simulation. This information establishes the cost of going from 20 to 26 training requirements as 616 million in period cost and 256 million in present value cost. To go from 20 to 30 training requirements costs 669 million in period cost and 393 million in present value cost. The system characteristics table shows the changes in flying hours and course lengths necessary to accomplish the increased training requirements.

TABLE L

SYSTEM COST DATA, TS-2/TS-3

	Gen -- 20 TR T-37 T-37 T-38	Gen -- 26 TR T-37 T-38	Spec -- 30 TR T-37 T-38 TA-4
Total System Outlay	[illegible],079	6,716	7,012
Terminal Value	(279)	(307)	(543)
Period Cost	5,800	6,409	6,469
Cost Savings Over Baseline	822	213	153
Present Value	2,920	3,174	3,313

TABLE LI

SYSTEM CHARACTERISTICS, TS-2/TS-3 SIMULATORS

	Gen -- 20 TR T-37 T-38	Gen -- 26 TR T-37 T-38	Spec -- 30 TR T-37	
			T-38	TA-4
Hands-on Flying Hours	106	122	13[illegible]	121
TS-2 Simulator Hours	68	72	72	72
TS-3 Simulator Hours	49	50	54	43
Course Lenght (Weeks)	50	55	55	
Aircraft Purchased	0	T-37: 100	T-37: 100 TA-4: 195	
TS-2 Simulators Purchased	96	112	112	
TS-3 Simulators Purchased	72	112	112	
Number of Bases	6	7	7	

No attempt should be made based on this data to establish other relationships of cost to training requirements. For example, it does not follow that if it were decided to train only 23 training requirements, the cost difference would be half of the value given to go from 20 to twenty-six.

The only way to establish meaningful cost differences between numbers (other than 20, 26, and 30) of training requirements is to accomplish a similar and complete analysis of each alternative and then compare the costs.

Cost of Simulation

The impact of simulation has already been described in terms of its potential for increasing training quality. Now the cost impact of simulation only will be presented. To do this, the cost of Concept I-A will be compared to the Baseline System. However, the Baseline had to be adjusted because the differences between the Baseline and Concept I-A include factors other than simulation. The primary adjustment made was to increase the course length of the Baseline case to incorporate the reduced training rate concept.

Table LII shows the standard Baseline, adjusted Baseline and Concept I-A with TS-2 simulators only and with TS-2 and TS-3 simulators applied. The table shows that the savings resulting from TS-2 amount to $578 million using period cost. The combined savings from TS-2 and TS-3 amounts to $848 million using period cost. These savings are for the 19-year period. However, the benefits of simulation are not able to be applied until 1976 for the TS-2 and 1983 for the TS-3.

TABLE LII

SYSTEM COST DATA
(Generalized 20 Training Requirements)

	Baseline		T-37 T-38 TS-2	T-37 T-38 TS-2/TS-3
	T-37/T-38 Standard	T-37/T-38 Adjusted		
Total System Outlay, $M	6,786	6,785	6,244	6,079
Terminal Value, $M	(164)	(137)	(174)	(279)
Period Cost, $M	6,622	6,648	6,070	5,800
Cost Savings Over Baseline,$M	--	--	578	848
Present Value	3,175	3,172	2,970	2,920

To present additional insight into the cost impact of simulation, Table LIII presents annual operating costs for comparison. From no simulation to TS-2 level simulation, the reduction in operating cost is estimated to be $40.1 million per year. When TS-2 and TS-3 are combined, the operating cost declines another $37.5 million per year. This is a combined total of 77.6 million dollars. If the cost of simulator DDT&E, investment, and facilities are amortized over a 15-year life, net annual savings of $31.0 million for the TS-2 and $25.3 million for the TS-3 simulator results. These cost saving projections are impressive. However, they do not present the complete cost impact picture of simulation. It must be remembered that simulation allows considerable extension of the trainer aircraft sufficiency dates and, thereby, delays the high investments cost necessary for aircraft replacement.

TABLE LIII

COST IMPACT OF SIMULATION
(20 Training Requirements, T-37/T-38)

	Costs, $M	
Annual Level-Off Operating Cost		
• T-37/T-38 with no simulation	348.1	
• T-37/T38 with TS-2 only	308.1	
Impact of TS-2		40.1
• T-37/T-38 with TS-2 and TS-3	270.6	
Impact of TS-3		37.5
	TS-2	TS-3
Reduction in Operating Cost	40.1	37.5
Annual Depreciation of Investment	9.1	12.2
Projected Net Annual Savings	31.0	25.3
Combined Annual Savings (TS-2 and TS-3)	$56.3 Million	

Cost of Replacement Aircraft ———

To determine the cost impact of introducing the new conceptual aircraft it is necessary to compare like systems and isolate the difference to the training aircraft. The cost of introducing the TA-2 aircraft compared to the alternative of extending the T-37 fleet sufficiency is found by comparing the cost of Concept II-A and II-B. Table LIV shows the difference in period costs of the two systems to be 153 million dollars. However, buying a new TA-2 aircraft results in a higher terminal value for Concept II-B which means it has potential past 1990.

TABLE LIV

SYSTEM COST DATA, TS-2/TS-3

	Generalized 26 Training Requirements	
	T-37 T-38	TA-2 T-38
Total System Outlay	6,716	6
Terminal Value	(307)	(
Period Cost	6,409	6,
Cost Savings Over Baseline	213	6,

The next consideration is the cost impact of replacing both the T-37 and T-38 with the TA-3 aircraft employed in Concept II-C. If Concept II-C is adopted, TA-3 delivery must begin in 1985, and full transition to the one aircraft system will take place while there is still fleet life remaining in the T-38. Because this remaining T-38 life could not be projected for use in UPT, no credit was given for the remaining value.

However, if the remaining T-38s could be d to meet some other Air Force requirement, n the cost impact of introducing the TA-3 uld have to be adjusted downward.

Table LV shows the difference in period cost of the TA-3 compared to the T-37/T-38 system to be $514 million -- all of which can be attributed to the investment cost of the new TA-3 aircraft.

The TA-4 conceptual aircraft cost is identified with both specialized training options and the question of cost impact of replacement does not apply.

TABLE LV

SYSTEM COST DATA, TS-2/TS-3

	Generalized 26 Training Requirements	
	T-37 T-38	TA-3
Total System Outlay	6,716	7,681
Terminal Value	(307)	(758)
Period Cost	6,409	6,923
Cost Savings Over Baseline	213	(301)

Sensitivity Analyses

No analysis would be complete without sensitivity examination of the UPT system factors. All the costs presented until now have been based upon single values for the various factors of each system. For instance, graduate production was set at 3665 graduates per year. These values are called the system design point values. They were developed as a part of the Mission Analysis and represent the values that apply best for each system under the circumstances investigated. However, these values must be expected to change since the undergraduate pilot training system is very complex and a 19 year period is being investigated. For example, since the mid-term of this study, graduate production has dropped from 4314 per year to 3665 per year. In order to evaluate the effect of future changes on system variables, a sensitivity analysis had to be considered. The simplified cost model previously described was the analytical tool used in accomplishing the sensitivity analysis.

The major part of the sensitivity analysis used the single factor approach, whereby the impact of changing one factor was determined by holding the other factors constant. This method provides good approximations of the cost impact that results from changes to the UPT program.

Twelve factors were considered initially. Table LVI shows the factors. The middle column shows the design point or nominal value about which excursions were made. The last column shows the range over which the factor was varied. For instance, graduate production was varied from 2500 graduates per year to 4500 graduates per year. Analysis of these 12 factors showed that six had a less than one percent impact on system cost for a 20 percent change in the factor value. The remaining factors and their impact on system cost are shown in Table LVII.

TABLE LVI

FACTORS CONSIDERED IN SENSITIVITY ANALYSES

Factors	Design Point	Range
Graduate Production	3665	2500-4500
Student Attrition, percent	10	1-26
Point of Attrition	0.2	0.1-0.9
Graduate Distribution, percent	40	32-50 FAIR
Syllabus	250 hrs	± 20
Simulation Percentage	30	0-90
Simulation Repl. Ratio	1:1	0.5:1-3:1
Utilization Rates	Various	± 20
Course Length	50 wks	± 20
Number of Bases	7	7,8,9
Maintenance Mn/Fh	Various	± 20
Student/Instructor Ratio	2:1	1:1-3:1

Using graduate production as the example again, the design point was 3665, 20 percent of that value is 735 graduates. Increasing production 735 graduates to 4400 raises system cost 16 percent. Dropping production the same amount, to 2930, causes a 16 percent decrease in cost. An increase in the first five variables causes an increase in cost. Increasing simulation, however, decreases cost (as simulator hours are increased, aircraft hours are decreased).

Another type of sensitivity data that provide good insight into the impact of changes to the UPT syllabus is the system cost per hour for equipment. Table LVIII shows a comparison of the costs of the major training equipments identified in the analysis. These costs were obtained by varying the syllabus that each equipment supports,

TABLE LVII

FACTORS WITH LARGE IMPACT

Factor	Factor Change, Percent	Cost Change, Percent
Graduate Production	+20	+16.0
Syllabus	+20	+10.0
Course Length	+20	+ 6.0
Maintenance Index	+20	+ 3.5
Student/Instructor Ratio	+20	+ 3.0
Simulation	+20	− 3.2

TABLE LVIII

COST FOR ONE HOUR CHANGE

Equipment	Equipment Cost per Hour Change	Annual Command Cost per Hour Change
TS-2	$122	$ 465,000
TS-3	$138	$ 525,000
T-37	$230	$ 990,000
T-38	$341	$1,416,000
TA-2	$232	$1,000,000
TA-3	$366	$1,520,000
TA-4	$317	$1,320,000

changing the course length the proper amount, and finding the resultant change in system cost. Column two shows the average additional cost of one student flying one more hour in each type of equipment. If a student used the TS-2 one more hour, the increase in cost would average $122; DDT&E investment and operating costs are included. Column three shows the total annual cost of all students flying one more hour. For instance, if the syllabus originally required 70 hours in the TS-2 and that requirement were increased to 71 hours with a concurrent increase in course length, the total increase in the annual command cost would be 465,000 dollars. Again, DDT&E investment and operating costs are included.

The sensitivity analysis provides a clear cost impact picture for the major factors in the UPT system. This information is useful if changes to any of the system factors are being considered.

Mission Analysis Summary

The major findings of the Mission Analysis have been identified and explained in this report. These findings are summarized below:

- Training requirements analysis has identified a need for higher quality training in Future Undergraduate Pilot Training.
- The number of training requirements called for in a given UPT curriculum determines if the program should be generalized or specialized. The Mission Analysis identified 30 candidate training requirements for Future Undergraduate Pilot Training. These 30 were grouped according to commonality in the force structure.
- The system approach to training is a most valuable concept and has been applied in all system options.
- The six system options identified in the decision tree represent optimum training packages for the number of training requirements specified and the equipment employed.

- A 10-percent attrition level in UPT is a realistic goal if centralized selection is employed and training improvements are implemented.

- Flight simulation will provide the breakthrough for increased training quality at lower cost. Findings support simulation for instrument training by 1976 and full mission simulation by 1983.

- The current trainer aircraft are adequate for the future. However, if the T-37/T-38 system options calling for increased training requirements are adopted, more T-37 aircraft will have to be purchased. In addition, both the T-37 and T-38 require avionics add-ons to operate in the Future UPT environment.

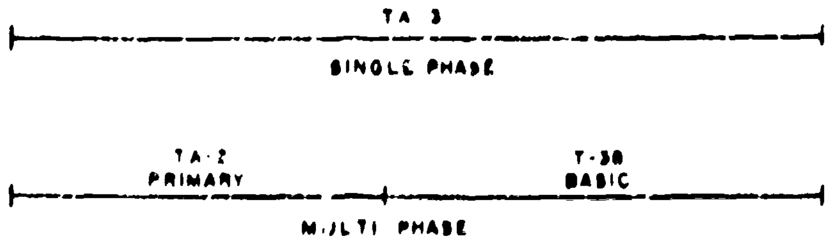
- The Air Force must identify an overall plan of action for Future UPT, which will provide the guidelines and time phasing for new training concepts and equipments.

The decision dates given in the report assume an overall plan decision date of January 1973.

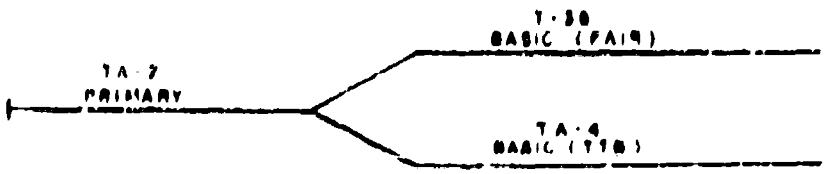
The major findings of the Mission Analysis have been presented. There remains, however, one important overall finding implicit in the structuring of the Future UPT system options and that is the requirement for overall management.

In a system as complex as Undergraduate Pilot Training, with its many external influences, it is necessary to employ a total management concept where long range management is employed vigorously and on a par with near-term management.

To realize the various milestones identified for the different system options, the individual system elements cannot be allowed to evolve at their own pace. There has to be long range management employed to ensure that proper priorities are maintained. The UPT Mission Analysis has provided the Air Force with an initial capability for the type of long range planning that is needed. If the impetus provided by the Mission Analysis is to be sustained, provisions must be made to incorporate this type activity into the decision making process on a permanent basis



(a) Generalized



(b) Specialized

Figure 38. Finalized Future UPT Options

STEERING COMMITTEE FINDINGS

The Mission Analysis Steering Committee received the final Study Group briefing on 17 December 1971. The Steering Committee had previously convened three times to evaluate the progress of the Study Group, and they were continually advised on major developments in the analysis effort. After the final briefing, the Steering Committee concurred with all of the major findings of the Mission Analysis. The following items were specifically addressed.

- The Steering Committee concurred with the major finding that higher quality training as expressed in additional training requirements above the 20 currently taught in UPT will be needed in future years.

- Training improvements identified should be pursued at Air Training Command. The systems approach to training, centralized student selection, reduced training rate, student management, and the training manager concept were highlighted for immediate attention.

- The application of flight simulation in UPT was recognized as the most significant finding of the Mission Analysis. The Steering Committee recommended that ATC take action to state an immediate requirement for TS-2 flight simulators and that AFSC investigate the feasibility of expediting the availability of TS-3 full-mission flight simulators.

- Alternative future UPT systems that require the procurement of additional T-37 aircraft were rejected due to the age of the T-37 design.

- Employing the above guidelines, the Steering Committee eliminated three of the six systems found to be feasible alternatives by the Mission Analysis. The three surviving systems are shown in Figure 34. These three remaining future UPT alternatives employ all jet aircraft, provide for increased training quality and include both generalized and specialized concepts. The decision to procure any new conceptual aircraft (TA-2, TA-3, or TA-4) would be deferred until the 1979-1982 time period.

- The Steering Committee recommended that ATC consider the feasibility of including a total of 28 training requirements in the generalized options. This would add "Basic Fighter Maneuvers" and "Air to Ground Fundamentals" to the list of 26 training requirements.

ANNEX I

ADMINISTRATIVE

REQUIREMENTS ACTION DIRECTIVE

PAGE 1 OF 1 PAGES

SUBJECT Future UPT System	NUMBER AND DATE 9-123-(1) 8 JAN 1969
ACTION ADDRESSEE AFSC (SCL)	INFORMATION ADDRESSEE See Attached List
REQUIRED ACTION (Briefly) Category C Mission Analysis	RELATED DOCUMENTS ATC ROC 5-68, 15 Jul 68, Chg 1, 11 Dec 68 RAD 9-76-1, 22 Oct 68 AFSC/SCTPL ltr, ATC ROC 5-68, 27 Nov 68 (NOTAL)

DIRECTION, PROPOSAL, CURRENT STATUS, GUIDANCE, FUNDS

DIRECTION. AFSC will initiate a Category C Mission Analysis Study to determine the desired characteristics and parameters of the Undergraduate Pilot Training (UPT) system for the 1975-1990 time period.

PROPOSAL. ATC has submitted a ROC which proposes a study to define a total UPT system suitable for acquisition and application in 1975 and beyond. An integrated management subsystem to control and manage the resources and assets of the UPT system is also desired.

CURRENT STATUS. RAD 9-76-(1) requested comments and recommendations from the major using commands. All of these have not been received. Copies of command responses will be furnished to AFSC when received. AFSC/AFHRL has reviewed a Lockheed unsolicited proposal to study and analyze the UPT program but recommends against funding the proposal. A similar Northrop unsolicited proposal is currently under review by AFHRL. After routine review of the ATC ROC, AFSC/SCTPL recommended that a Category C Mission Analysis Study be undertaken by AFSC. The Air Staff has reviewed the ATC proposal and agrees that a mission analysis is required.

GUIDANCE. AFSC will identify and solicit the required participation of ATC and the major using commands as well as the Air Staff and other interested agencies. Commands and agencies will respond as appropriate within the limits of their functional responsibilities.

MANPOWER/FUNDS. This study will be initiated as an "in house" effort. No additional manning or funds have been identified or authorized at this time. As the mission analysis develops, if a requirement for contractual support is identified which is beyond AFSC fund resources, this headquarters will be advised so that necessary funds may be sought.

ORIGINATOR'S NAME, ADDRESS, TELEPHONE NO. Lt Col Corvey/AFRDQRA/79637	SIGNATURE OF APPROVING OFFICER William [illegible]

"FORCING MILITARY SPACEPOWER"

AFSC PROGRAM DIRECTION

DATE RELEASED: JUN 1969

TO:	FROM:	NUMBER
ASD (ASCP)	AFSC (SCLTG) Andrews AFB Wash DC 20331	C062-1-69-345

I. PROGRAM IDENTIFICATION

1. PROGRAM ELEMENT	2. TITLE	3. AFSC PROGRAM NUMBER
63101F	Undergraduate Pilot Training (UPT) System Program	C062

4. AFSC PRIORITY	5. USAF IMPORTANCE CATEGORY

6. PURPOSE

To assign to ASD responsibility for: (1) arranging for the Air Force to contract for preliminary studies as described in the Summary Statement of Work; and (2) monitoring contractor efforts under said contracts.

7. ATTACHED DOCUMENTS AND RELATED REFERENCES

ATC ROC No. 5-68, Future Undergraduate Pilot Training (UPT) System, 15 Jul 68.
RAD 9-76-(1), same subject, 22 Oct 68.
Change #1, 11 Dec 68, to ATC ROC No. 5-68.
RAD 9-123-(1), Future UPT System, 6 Jan 69.
Summary Statement of Work, 30 Apr 69.
HQ USAF(AFRDO) ltr, Undergraduate Pilot Training, dtd 16 May 69.
D&F Auth to Neg Contracts 7 Jul 68.
Final Procurement Action App. 13 Jul68

II. MANAGEMENT APPROACH

9.
- [ ] SYSTEM MANAGEMENT
- [ ] ADVANCED DEVELOPMENT MGT
- [ ] EXPLORATORY DEV
- [ ] TEST INSTRUMENTATION
- [ ] OPNL SUPPORT
- [X] STUDY AND ANALYSIS
- [ ] OTHER (Explain)

9. CONCEPT AND APPLICATION

The Air Force will conduct a Mission Analysis study to analyze and assess the options available to the Air Training Command (ATC) and recommend preferred undergraduate pilot training system characteristics and parameters for the 1975-1990 time period. Contractor support is required to provide data, technological forecasts and options, particularly in the area of training concepts, instructional innovations and the use of simulators. ASD will contract for such studies, using funds and guidance provided by this Headquarters.

10. PARTICIPATING ORGANIZATIONS AND MANAGEMENT RELATIONSHIPS

ASD is designated lead division.
ATC is using command
The Human Resources Laboratory (AFSC/HRL) will assist in an advisory capacity.

This program direction is the fully coordinated result of HQ AFSC staff review, and in conjunction with applicable directives, and prescribed deviations, constitutes complete direction for action. Unless otherwise specified, correspondence, including fully substantiated requests for waiver of compliance will be directed to the HQ AFSC staff or OPR identified in this directive.

III. APPROVAL AND CONFIRMATION

11. HQ AFSC STAFF OPR APPROVAL	12. HQ AFSC DIRECTOR PROGRAM/BUDGET CONFIRMATION
Edgar N. Munyan [illegible], Colonel, USAF	G. E. Myers G. E. MYERS Deputy Director of [illegible]

AFSC [illegible] PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE

DOCUMENTATION

13.

☐ DD FORM 1498 ☐ DEVELOPMENT PLAN ☐ PCP

☐ CFP/TDP ☐ PSPP ☐ SPP

☐ ESP ☒ OTHER (Explain in Deviations)

14. DEVIATIONS (Include reference to the appropriate directive and explain any authorized deviations)

a. Submit a report to this Headquarters upon awarding study contracts, to include results of negotiations with selected sources, problems encountered and anticipated, and comments as appropriate.
b. Provide this Headquarters with copies of the contractors' basic study assumptions and base line descriptions, with ASB comments as appropriate. (Cont'd below)

15. NUMBER OF COPIES	16. DOCUMENTATION DUE HQ AFSC (SCCP) NOT LATER THAN
See below	15 days following end of each rptg period.

17. TECHNICAL DIRECTION (To be completed by the staff OPR to provide essential guidance of a technical nature)

ASB will be responsible for contractual action necessary to procure initial studies for this effort as defined in the Summary Statement of Work. ASB will also monitor the contractors' efforts during contract performance and will provide guidance to the contractors as necessary.

18. FUNCTIONAL DIRECTION

Manpower and Organization: The directed actions will be accomplished by personnel currently available within ASB resources.

Personnel: None

Financial: FY 69 funds in the amount of $850K have been released by PA/BA #238 to from P.E.63101F for this effort. Exception has been granted to obligate and ed finance this effort subsequent to 31 July 1969.

Material: N/A

Safety: N/A

Procurement: Expedite preparation of RFP and any necessary procurement planning in order to accomplish negotiation and complete contract award by 15 August 1969.

14. (Cont'd)

c. Provide copies of the contractors' plans for interfacing with other USAF agencies in quest of data.
d. Forward the contractors' quarterly reports to this Headquarters, along with a status report prepared by ASB to include funding information, problems, appropriate comments, etc.
e. Forward contractors' final reports, with final ASB report.

15. 10 copies of all ASB reports; 50 copies of contractors' quarterly reports; 100 copies of contractors' final reports.

UPT MISSION ANALYSIS

STEERING COMMITTEE

Major General John R. Murphy, Hq ATC	Vice Commander, Chairman
Major General John B. Kidd, Hq USAF	DCS/Personnel
Major General Clare T. Ireland, Hq MAC	DCS/Operations
Brigadier General Kenneth R. Chapman, Hq AFSC	DCS/Development Plans
Brigadier General Cuthbert Patillo, Hq TAC	Asst DCS/Operations & Training
Brigadier General Lawrence W. Steinkraus, Hq SAC	Director of Command & Control
Brigadier General J.J. Burns, Hq USAF	Deputy Director for General Purpose Forces
Colonel Ronald T. Adams, Jr, Hq ADC	Asst DCS/Operations

STUDY GROUP

Name	Organization	Duty Title
Full-Time Members		
Col Colin J.N. Chauret	ATC/DOS	Director
Mr Robert R. Swab	ASD/XRL	Deputy Director
Col John L. Webb	ATC/DOT	Member
Major Roy L. Ripley	ATC/XPQS	Member
Major James B. Gilbreath	ATC/XPQS	Member
Major Robert G. Bradshaw	ATC/DOT	Member
Capt William R. O'Rourke, Jr	ATC/DOV	Member
Capt Robert A. Thompson	ATC/DOT	Member
Mr Vladimir Vukmir	ASD/XROL	Operations Research Analyst
Mr Curtis Yelverton	ATC/ACMF	Cost Analyst
Capt Michael W. Conley	ATC/XPXA	Operations Research Analyst
1st Lt Randall D. Burris	ATC/DMLA	Operations Research Analyst
Miss Liz Owens	ATC/ACMF	Cost Analyst
Mr James E. Brown	AFHRL/FT	Simulation
Mrs Janis (Angell) Riehl	ATC/CVZ	Technical Writer/Editor/Publicationist
Full-Time Administrative Support Office		
MSgt Homer Brock	ATC/CVZ	Chief of Administration
Mrs Deloris Breske	ATC/CVZ	Administrative Assistant
Mrs Jeaun Cornue	ATC/CVZ	Clerk Typist
Mrs Mary Gagne	ATC/CVZ	MTST Typist
Mrs Wanda Phillips	ATC/CVZ	Clerk Typist
Mrs Vada Pringle	ATC/CVZ	MTST Typist

Part-Time Members

Mr Dennis K. Leedom	ASD/XROL	Operations Research Analyst
Mr Richard O'Brien	ASD/XRHI	Trainer Aircraft
Capt Jack Robbins	ASD/XRVS	Equipment Scheduling
Capt Ray Mager	ASD/XRVE	Aircraft & Avionics Cost
Major Floyd W. Brown	USAF/DPTTF	UPT Production Rates
Major Edward P. Roscoe	AFSC/XRLA	UPT Graduate Assignment Distribution
Mr Milton Wood	AFHRL/FT	Learning Center and Dynamic Observer
Dr Ronald A. Guebel	AFHRL/FT	Student Evaluation
Capt L. Baer	AFHRL/FT	Peer Instruction
Dr. Lonnie Valentine	AFHRL/PD	Student Pool & Selection
Dr. Robert Miller	AFHRL/PD	Student Pool & Selection
Mr. Arthur T. Gill	AFHRL/TTS	Flight Simulation
Mr. Arthur B. Doty, Jr	ASD/ENCTS	Flight Simulation
Mr. Sean Gibino	ASD/ENCTS	Flight Simulation
Mr. Joe A. Naranjo	ATC/DOTSD	Systems Approach to Training
Major Frank A. Buchanan	ATC/DOTA	Airspace & Air Traffic Control
Mr. Jack F. Robson	ATC/DEPL	Facilities
Mr. Robert H. Hugman	ATC/DEECX	Simulator Facilities
Mr. C.L. Westervelt	ATC/ACDSP	Systems Analyst
Mrs. Joan Ballard	ATC/ACDSP	Computer Programmer

Midterm Review Panel

Col John S. Paulisick	ASD/XR	Chairman
Dr. William V. Hagin	AFHRL/FT	Member
Dr. Gordon A. Eckstrand	AFHRL/TT	Member
Col W. Steward (Ret)	RAND	Member
Dr. Paul W. Caro	HumRRO	Member
Dr. Don L. Meyer	ATC/XPT	Member
Col L.E. Bouquin	ATC/DO	Member
Col F.H. Mason	ASD/ENC	Member
Brig Gen J.T. Stewart	ATC/DM	Member
Col William J. Gilbert	ATC/DOT	Member
Col J.C. Phipps	ATC/XPT	Member
Major H.A. Davis	MPC/DPMR	Member
Lt Col Thomas Hisbay	Hq USAF	Member
Maj Paul T. Kemmerling	ASD/ENCCF	Member
Mr William E. Mooz	RAND	Member
Mr. Emil W. Lee	Hq USAF/ACB	Member

Consultants

Mr. Ralph E. Flexman	USAF SAB	
Lt Col Robert A. Norton	Hq SAC/DOTF	Training Requirements
Major John R. Hume	TAC/4443 CCTW DOT	Training Requirements
Major Allan C. Johnson	MAC/443 TW/DOT	Training Requirements
Major Randall Krumback	Hq TAC/DOOTS	Training Requirements
Capt Arthur Pany	Hq ADC/DOTV	Training Requirements
Mr Don Gum	AFHRL/TRS	Flight Simulation
Mr. James Basinger	AFHRL/TTS	Flight Simulation
Miss Patricia Knoop	AFHRL/TTS	Flight Simulation
Capt Perry Hair	AFHRL/FT	Flight Simulation
Mr. James F. Smith	AFHRL/FT	Flight Simulation
Dr. Sylvia Mayer	ESD/MCDS	Computer Based Instruction